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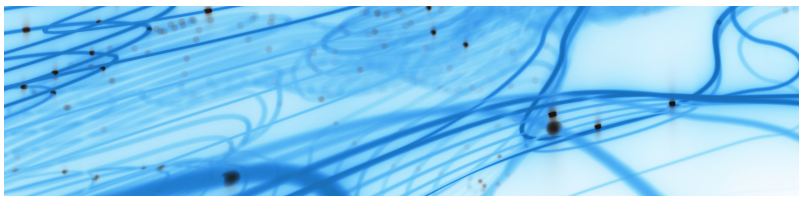

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Review Article

Current updates in acute traumatic aortic injury: radiologic diagnosis and management

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Acute traumatic aortic injuries, which have substantial lethal outcomes at the time of admission, are fatal in 80% to 90% of cases. These injuries are relatively rare and have nonspecific clinical presentations. Radiologists and emergency physicians need to identify the radiological signs of acute traumatic aortic injury and differentiate them from common imaging errors to ensure accurate diagnosis and determine appropriate management protocols. In combination with image-guided interventions, advances in cross-sectional imaging have enabled nonsurgical management of acute traumatic aortic injuries. Timely and precise diagnoses of these injuries following prompt treatment are essential as up to 90% of patients presenting at the hospital can undergo early repair.

Keywords Aorta; Injuries; Angioplasty; Endovascular procedures

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Capsule Summary

What is already known

Acute traumatic aortic injuries are associated with substantial lethal outcome at the time of admission fatal in 80% to 90% of cases. These injuries are relatively rare and have nonspecific clinical presentation. Early identification of the radiological signs of acute traumatic aortic injuries and differentiation from common imaging pitfalls are essential to facilitate the diagnosis of these injuries and help decide the management protocol.

What is new in the current study

Our article provides a comprehensive and updated review on the diagnosis and management of acute traumatic aortic injury, which will be useful for both emergency physicians and radiologists.

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INTRODUCTION

Acute traumatic aortic injuries (ATAIs), which have substantial lethal outcomes at the time of admission, are fatal in 80% to 90% of cases.[1-3] These injuries are relatively rare and have nonspecific clinical presentations. Male patients, and particularly young male patients between the ages of 30 and 40, are more commonly affected by ATAI.[4]

The most common location for an imaged ATAI is the aortic isthmus (approximately 90%), just distal to the origin of the left subclavian artery, because of the relative immobility of the aorta at the site of the ligamentum arteriosum.[5,6] The other sites of ATAI in the thorax are, in descending order of frequency, the ascending aorta/aortic root (5%–8%), aortic arch (2%), and distal descending aorta (1%–12%).[5,7,8] Injuries that cause aortic tears at more than one location are reported in 6% to 18% of cases.[7]

Blunt trauma due to a high-velocity impact, such as a motor vehicle collision, is the most common mode of injury, accounting for 70% of cases, followed by a fall from height.[9] Various mechanisms have been proposed for the processes that lead to ATAI. These include shearing forces, rapid deceleration, hydrostatic forces, and the osseous pinch.[5,9] Rapid deceleration in the anteroposterior and lateral directions results in torsion and shearing forces against the aorta at relatively immobile levels. Another mechanism is a sudden increase in intra-aortic pressure, which can exceed 2,000 mmHg, following direct compression.[10] This has been termed the "water-hammer effect," and results primarily in horizontal tears of the isthmus but may also show retrograde extension with injury at the aortic root.[11] In the osseous pinch mechanism, anterior chest-wall bones (clavicles, ribs, and the manubrium) directly compress the aorta against the spine.[12] Direct injury to the aorta can occur in penetrating trauma as gunshot or knife wounds with severity related to the trajectory of the weapon.[13,14] Knowledge of the mode of injury that may result in an ATAI should warrant radiological imaging.

Cases of ATAI of the abdomen account for 11% to 15% of aortic injuries.[14] The frequency of abdominal aortic injuries is much lower than that of thoracic aortic injuries because the abdominal aorta is relatively well protected.[14-16] The divisions of abdominal aorta most commonly involved with trauma are, in descending order of frequency, infrarenal (67%), suprarenal (33%), and extension from a thoracic aortic injury (25%).[16] Abdominal aortic injuries are frequently a result of a crushing injury between the lumbar spine and lap belt. Shearing forces do not play a major role in abdominal aortic injuries.[7] Abdominal aortic injury patients commonly have neurological deficits ranging from sensory loss to paraplegia.[7]

ETHICS STATEMENT

As a teaching institute, All India Institute of Medical Sciences obtain consent from all patients prior to all procedures and other management for using their data for educational and teaching purpose. Also, we have neither used any clinical image nor revealed any other patient information as all radiology images are anonymized.

CLINICAL PRESENTATION

Clinical features are often unreliable for diagnosis or exclusion of ATAI. Patients may present with nonspecific and variable clinical signs and symptoms, such as chest pain, back pain, breathing difficulty, external chest-wall injuries, and increased chest-drain output, depending on the mechanism and magnitude of the injury.[17] In fact, the signs of aortic damage may not be recognized clinically until sudden hemodynamic instability. Hypotension, upper-limb hypertension, and lower-limb hypotension with reduced femoral pulses (pseudocoarctation syndrome), and differences in blood pressure between the right and left brachial arteries are warning signs suggestive of aortic injury. However, these signs are absent in up to one-third of patients.[5,13,18] An evaluation of concomitant visceral injuries that may be immediately life-threatening is essential and should take priority over management of aortic injury. Attention to fractures of the sternum and first and second ribs, clavicle, and/or scapular fractures, pneumothoraces, hemothoraces, flail chest, pulmonary contusions, diaphragm injury, tracheobronchial disruption, and esophageal injuries in high-impact trauma is essential for the effective management of high-risk ATAI. Other common concomitant injuries are severe head injury, lung and cardiac injury, diaphragmatic rupture, intra-abdominal bleed, pelvis trauma, and long bone fractures.[9]

DIAGNOSTIC IMAGING

Chest X-rays

A supine chest X-ray (CXR) offers an adjunct to primary assessment and is the first line of imaging in acute trauma.[19] It can diagnose immediate life-threatening conditions such as tension pneumothorax or large hemothorax, and evaluate the position of tubes and lines.[13,14,20] Although CXR has high sensitivity of 90% in detecting mediastinal hemorrhage, the specificity is low, as there are other causes of mediastinal hematoma.[21] A CXR can rule out ATAI in most cases, however a small percentage (0.5%–7%) of patients with normal CXRs may actually have ATAI.[22] Patients suspected to have suffered an ATAI should undergo further

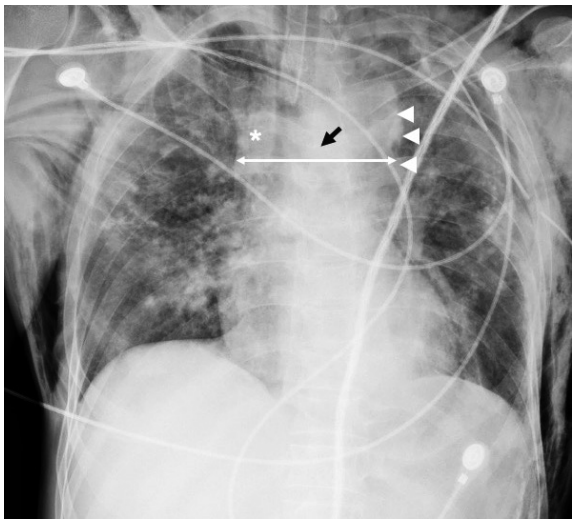

Fig. 1. Chest X-ray depicting mediastinal widening (double arrow) at the level of the aortic knob, along with obscuration of aortic contours (arrowheads) in a posttraumatic patient. Note the right paratracheal stripe widening (asterisk) and the depression of left mainstem bronchus (black arrow). The findings are highly indicative of aortic injury.

imaging.[21]

Radiographic signs in acute traumatic injury of thoracic aorta are as follows (Fig. 1).[13,14,20,21] A widened mediastinum of more than 8 cm and/or 25% of the thoracic width (at the level of the aortic knob) is the most frequent observation. It is highly sensitive (81%–100%) and can detect mediastinal hematoma, but the specificity is low (34%–60%) as venous bleeds and sternal and vertebral fractures can also lead to mediastinal bleeds.[22] This technique is also associated with false positivity because the supine position and anteroposterior view lead to projectional variability of the mediastinal silhouette.

Loss of aortic knob or aortopulmonary window contour is the most consistent and reliable sign of ATAI of the thoracic aorta. Cases without mediastinal widening, but with loss of the sharp interface of the lung and the transverse or descending thoracic aorta, should be considered suspicious, as aortic contours should have a well-defined interface with the adjacent lung and aortopulmonary window. When applied in conjunction with mediastinal widening, this radiographic sign provides superior diagnostic accuracy.

Depressed left mainstem bronchus (more than 40 degrees from the horizontal), deviated trachea, or support devices, including endotracheal and enteric tubes toward the right (to the right of the spinous process of the third or fourth dorsal vertebra) are also indicative of ATAI and manifest due to the mass effect of mediastinal hematoma.[22]

The left apical pleural cap is an occasionally seen in ATAI and occurs due to bleeds coursing along the left subclavian artery reflection.[5,22] The left apical cap is reportedly not specific for aortic injuries, and other causes, such as pleural thickening, hematomas from central venous pressure-line placement, rib fractures, clavicular fractures, or subclavian arterial trauma, must be considered. Thickening by more than 5 mm of the right paratracheal stripe and the left hemothorax may be present in ATAI.

A combination of these positive signs add to the diagnostic value of CXR for ATAI. In a patient with a high-energy impact, mediastinal widening with loss of aortic contours on CXR is highly indicative of ATAI and warrants further investigation with multidetector computed tomography (MDCT) and CT angiography (CTA).

Focused assessment with sonography for trauma

Focused assessment with sonography for trauma (FAST) can detect hemothorax and pericardial effusion, which may occur in the event of a free aortic rupture. However, FAST has low sensitivity and specificity in detecting ATAI.[23]

Multidetector computed tomography

With the advent of modern technology, MDCT has superseded digital subtraction angiography (DSA) for the detection of ATAI.[17] MDCT with CTA is now the tool of choice for detecting aortic injury, offering 98% sensitivity and 100% specificity in the evaluation of suspected ATAI.[9] Contrast-enhanced MDCT is favored for assessments of polytrauma patients and is considered an appropriate imaging modality that can reliably exclude ATAI, with a negative predictive value approaching 100% in some studies.[12] Few studies have suggested that single-phase contrast-enhanced CT provides comparable accuracy.[24] Electrocardiogram gating is not mandatory in trauma settings as setup times can be lengthy and require patients to hold their breath for extended periods.[9] The drawbacks associated with motion-related artifacts at the aortic root and heart and breathing artifacts have largely been overcome by ultrafast acquisition in newer dual-energy CT machines.[9] The acquired CT scans are then analyzed on three dimensional workstations to evaluate aortic injuries using multi-planar reformations, which provide information on the extent and grade of injury and depict the relationship and distance of the injury to the left subclavian artery.[24] An ATAI is best visualized in the sagittal-oblique plane of the thoracic aorta, simulating a projection obtained from conventional angiography.[25]

CT Signs of ATAI

Most ATAIs (approximately 90%) occur along the antero-medial aspect of the aortic isthmus.[7] The CT signs of ATAI can be either direct or indirect, based on the presence or absence of signs of

Table 1. Computed tomography signs of acute traumatic aortic injury

Direct sign	Indirect sign
Intimal flap	Periaortic hematoma, in close proximity with aorta and no intervening fat plane
Intraluminal and mural thrombus	
Focal wall outpouching	
Abnormal aortic contour	
Sudden change in aortic caliber (aortic "pseudocoarctation")	
Periaortic contrast extravasation	

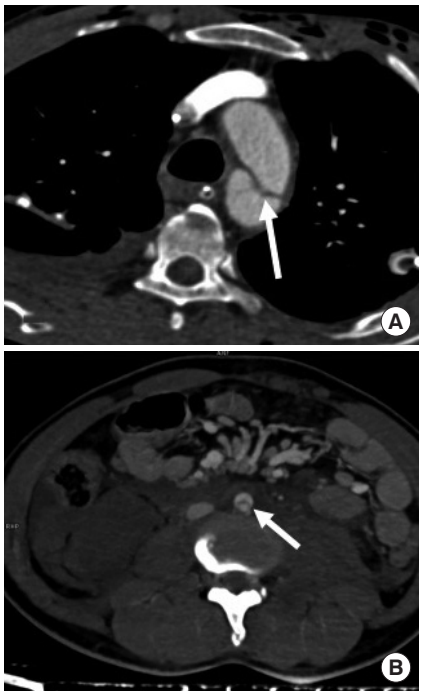

Fig. 2. Intimal flaps in aorta. An intimal flap can be seen as a sharp, linear filling defect (arrow) in two different patients in (A) thoracic aorta and (B) abdominal infrarenal aorta.

alteration of the aortic wall itself, as summarized in Table 1.[8] The diagnostic accuracy of CT has been found to be 100% in the presence of direct signs.[12] Patients with direct signs of ATAI on MDCT require no further imaging to avoid delays in timely management.

Direct signs are defined on the basis of degree of injury to aortic wall with intimal, medial, and adventitial injuries displaying different radiological manifestations.[4,13,14] These include the presence of an intimal flap, intraluminal and mural thrombus, focal-wall outpouching, aortic dissection, abnormal aortic contours, sudden changes in aortic caliber (aortic "pseudocoarctation"), and periaortic contrast extravasation.[4,13,14]

An intimal flap is seen as a linear filling defect within the aortic lumen as a result of an intimal tear (Fig. 2).[17] An intraluminal thrombus appears as a globular, intraluminal filling defect repre-

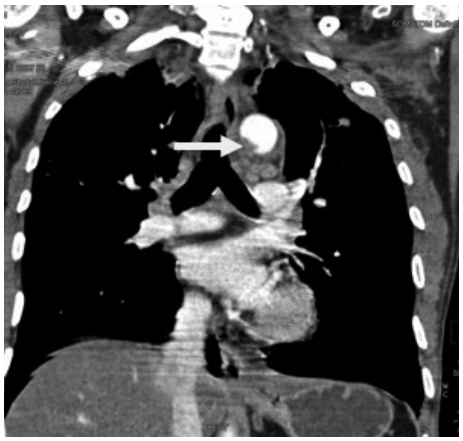

Fig. 3. An intraluminal thrombus in the aorta. An intraluminal thrombus can be seen as a globular, filling defect within the aortic lumen (arrow).

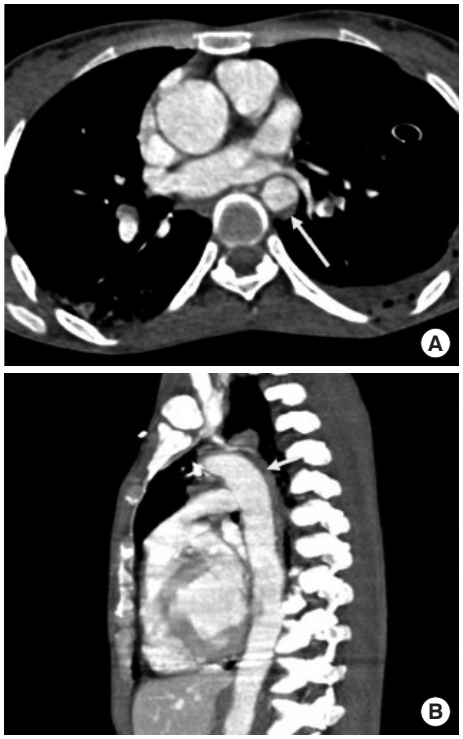

Fig. 4. Intramural hematoma in the aortic wall. It presents as a crescent-shaped density in the aortic wall (arrow) in (A) axial and (B) sagittal oblique images.

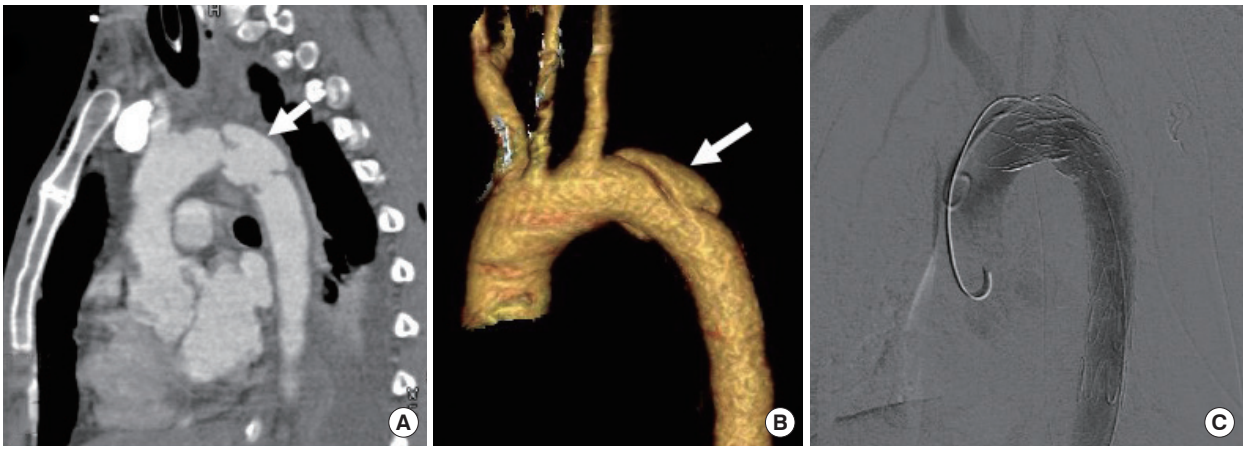

Fig. 5. A pseudoaneurysm. An abnormal aortic contour with focal bulge (arrow) just distal to subclavian artery in (A) maximum intensity projection oblique sagittal images and (B) volume rendering technique images. (C) This case was treated with endovascular stent graft placement.

senting a thrombus secondary to intimal damage (Fig. 3).[14] An intramural hematoma is visualized as a hyperdense crescent in the aortic wall (Fig. 4).[9]

Focal-wall outpouching or an abnormal aortic contour (pseudoaneurysm), as depicted in Fig. 5, reflects focal damage to both the tunica intima and media, with adventitia remaining as the outermost intact layer retaining blood.[17] Focal-wall outpouching is the result of the highly compliant nature of the adventitia, which is at risk of rupture if not treated. Harris et al.[26] developed a risk score for assessing aortic stability and prognostications regarding rupture; the parameters include admission lactate >4 millimoles, pseudoaneurysm/normal aortic diameter ratio >1.4 (Fig. 6), and mediastinal hematoma thickness along the descending thoracic aorta >10 mm. They concluded that there is an increased risk of aortic rupture in the presence of any two of these factors.[26] Untreated or undiagnosed injuries can develop into chronic pseudoaneurysms in 1% to 2% of patients,[6] who may be thrombosed with dense peripheral calcification.[25]

Periaortic contrast extravasation is the most apparent direct sign and represents a tear of the full thickness of the aorta (Fig. 7). It is essential to understand that the absence of active extravasation does not exclude an aortic transection, as intraluminal contrast within a completely transected aorta remains within the confines of the periaortic connective tissue.

Indirect signs include periaortic hematoma (mediastinal hematoma in the thorax and retroperitoneal hematoma in the abdomen), as depicted in Fig. 8, and are usually a result of the avulsion of perivascular veins from the arterial vasa vasorum rather than extravasation of intraluminal blood from the vessel itself.[4,13,14,25] In an ATAI, the hematoma is in direct contact with the aorta, with an indistinct intervening fat plane between hematoma and aorta.

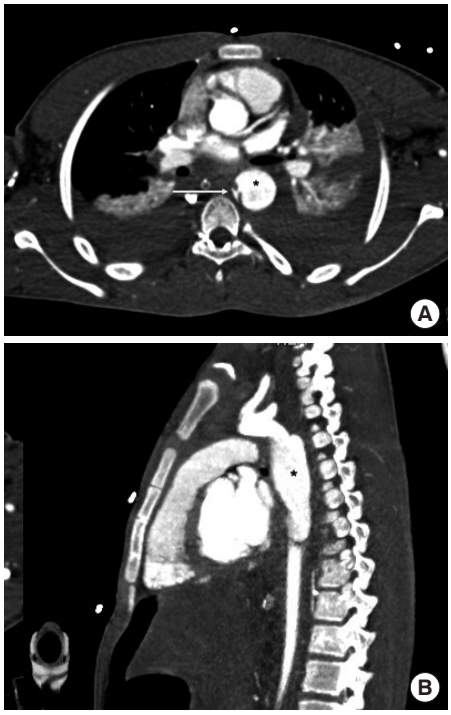

Fig. 6. Pseudoaneurysm with pseudocoarctation. A focal-contrast-filled outpouching (asterisk) leading to a significantly compressed aortic lumen (arrow) in (A) axial multidetector computed tomography images and (B) oblique sagittal maximum intensity projection images. A pseudoaneurysm/normal aortic diameter ratio >1.4 is a predictor for rupture.

This finding helps exclude mediastinal hematoma due to venous mediastinal bleeding, sternal/vertebral body fractures, or intercostal arteries hematoma.[4,14,25] In the presence of such periaortic hematomas, physicians should look for signs of direct aortic injury. However, an ATAI may be present despite nonvisualization of periaortic mediastinal hematoma when the injury is confined to

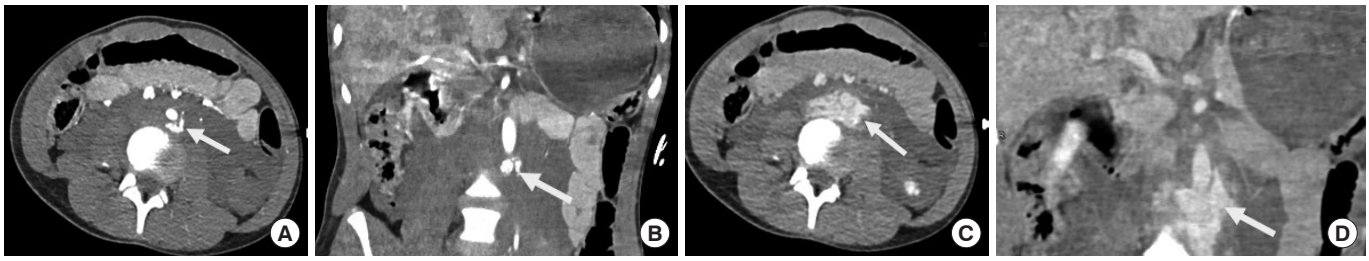

Fig. 7. Periaortic contrast extravasation. (A) Axial and (B) coronal reformatted computed tomography images in the arterial phase show an ill-defined focus of extravasated contrast matching the blood pool (arrow) in a retroaortic location with significant retroperitoneal hemorrhaging. In (C) the corresponding axial and (D) coronal reformatted portovenous phase images, the extravasated contrast (arrow) is shown expanded and spreading around the aorta.

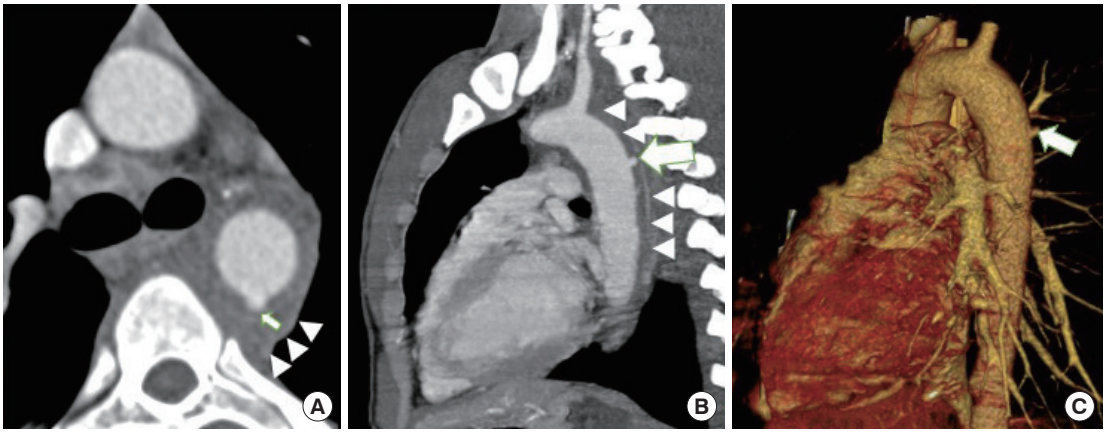

Fig. 8. Periaortic hematoma surrounding the aorta. Periaortic hematoma (arrowheads) can be seen closely surrounding the aorta with no intervening fat in (A) and (B). A closer look leads to a tiny focal pseudoaneurysm (arrows) as seen in (A) axial, (B) oblique sagittal, and (C) volume rendering technique images.

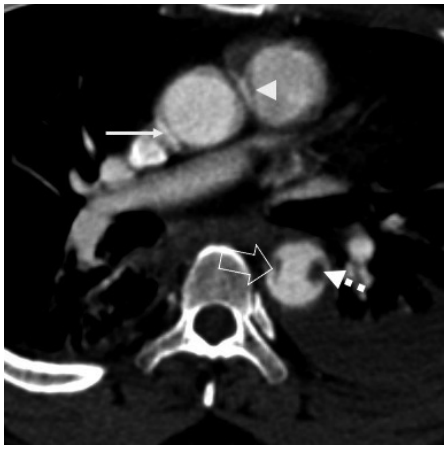

Fig. 9. A pulsation artifact at the aortic root (arrow) mimicking an intimal flap. The fuzzy margins and simultaneous artifact in the main pulmonary artery (white arrowhead) helps distinguish the true injury from artifacts. Also seen in the same section is a traumatic intimal flap (blank arrow) with sharp margins in the descending aorta. An intraluminal thrombus (dashed arrow) is adjacent to it.

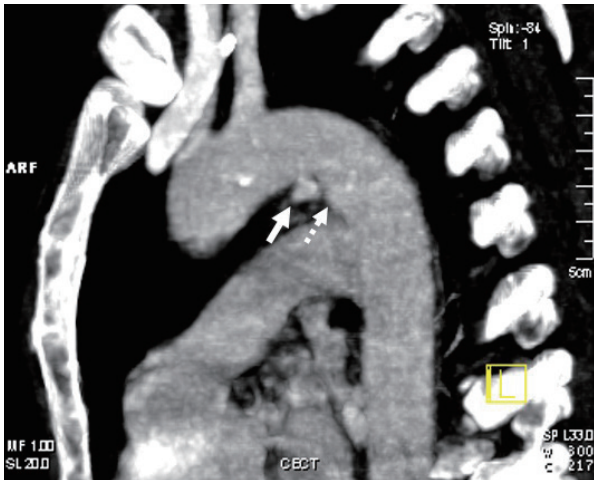

Fig. 10. Ductus diverticulum versus pseudoaneurysm. A traumatic pseudoaneurysm is seen as a focal contour bulge (solid arrow) forming sharp margins with the aorta. In contrast, the ductus diverticulum (dashed arrow) has a smooth focal bulge, broad neck, and gentle obtuse angles with the aortic wall.

the intima. Periaortic hematoma in the absence of direct signs of aortic injury could be due to an occult intimal injury. Intravascular ultrasound or transesophageal echocardiography can supply definitive details in such cases.[9]

Pitfalls of CT angiography

Imaging errors can be technical or anatomical. Technical pitfalls include pulsation, breathing, and motion artifacts.[8] Pulsation artifacts are usually seen at the aortic root and in the ascending aorta and mimic intimal flaps (Fig. 9). Traumatic intimal flaps have sharp margins while those arising due to artifacts have fuzzy margins. Simultaneous artifacts in the main pulmonary artery can also help distinguish a true injury from an artifact. An electrocardiogram-gated CT scan can be performed in cases in which dilemmas cannot be solved.[13] An artifact due to movement or breathing mimics an intimal flap and appears to be projecting over the lumen and adjoining mediastinal fat or lung parenchyma.

Several anatomical variants can cause confusion in assessments of ATAI. The most common anatomical variant is ductus diverticulum. This is an embryonic ductus arteriosus remnant. A ductus "bump" has been reported in approximately 9% of the general population.[4] Differentiation of ductus diverticulum from a traumatic focal contour bulge is critical as both are seen at the site of the aortic isthmus (Fig. 10). Ductus diverticulum is usually present in the inferior aortic arch at the level of the aortic isthmus and has a smooth focal bulge, a broad neck, and gentle obtuse angles with the aortic wall.[14] This is in contrast to traumatic focal contour bulges, which usually form sharp margins with the aorta and are often associated with signs of regional trauma, such as an intimal flap or periaortic hematoma. The presence of calcification favors ductus diverticulum over an ATAI.[14] Other anatomical structures that can introduce diagnostic uncertainty include the aortic spindle and the ostium of branch arteries. The aortic spindle has a fusiform dilated appearance and is distal to aortic isthmus. As a nonpathological dilatation of bronchial, intercostal, lumbar, and sacral arteries, ostia may mimic a tiny pseudoaneurysm; however, the appearance of an artery at the distal end of the conical ostium can help reach a diagnosis. Simultaneous opacification of the aorta and adjacent veins (hemiazygos, intercostal, or bronchial veins) often results in a false appearance of an intimal flap.[4] Enhancement of a small and collapsed adjacent lung may also simulate an intimal flap; however, tracing pulmonary vessels and bronchi into the collapsed lung can confirm the diagnosis.[4] While residual thymic tissue can mimic a hematoma, the characteristic triangular shape of thymic tissue and the absence of accompanying fat stranding can help reach a conclusion. Pericardial recesses can also be mistaken for mediastinal or intramural hematoma. Fluid attenuation and the preserved fat plane between the recess and the aorta can help distinguish this normal structure from a mediastinal hematoma. Knowledge of the location of anatomical structures and scrolling through sequential images should eliminate diagnostic confusion.

Digital subtraction angiography

Historically, DSA was considered the gold standard to diagnose ATAI, with a sensitivity of nearly 100%, a specificity of greater than 98%, and accuracy of more than 99%. However, with the advent of MDCT and its high ATAI sensitivity and specificity, DSA is now reserved for endovascular intervention or patients with lateralizing signs of ATAI but lacking definitive signs on CT. The signs of ATAI on DSA are vessel-wall irregularity, including breaches in continuity, contrast-material extravasation in the event of complete rupture, pseudoaneurysm, and pseudocoarctation.[4] Transesophageal echocardiography can be used bedside if the patient is unstable and other examinations are impossible.

Magnetic resonance imaging (MRI) has a limited role in the detection of ATAI due to long acquisition time, the need for patient immobility, and difficulty introducing certain support systems into an MRI room. However, because of the advantage of MRI characteristics in detecting aortic trauma, it can be useful in monitoring intimal injuries, follow-ups after endovascular stent placement, delayed elective surgical repair, and, in young patients, reducing radiation exposure.[9]

Intravascular ultrasound is a helpful adjunct in scenarios in which CTA findings are equivocal because it provides cross-sectional images of the vessel wall and adjoining tissues at high resolution.[9] Angiography may not reveal any abnormality in approximately 50% of patients, and intravascular ultrasound may help reach a proper diagnosis.[7]

CLASSIFICATION OF ACUTE TRAUMATIC AORTIC INJURIES

The importance of classifying injuries lies in identifying features that point to a poor prognosis, underlining the importance of correct use of MDCT signs. Various classification systems have been used in recent years to define the severity of ATAI, the most widely used of which is Society of Vascular Surgery (SVS) classification.[27]

Direct signs of ATAI detected on MDCT can be classified according to SVS as grade 1 (intimal flap), grade 2 (intramural hematoma), grade 3 (pseudoaneurysm), and grade 4 (rupture), based on anatomical layers of the aortic wall.[28]

The Harborview classification simplifies the SVS grading criteria of ATAI into minimal, moderate, and severe categories, on the basis of differences in treatment among these three categories (Table 2).[29]

Minimal aortic injury (MAI) includes SVS grade 1 and 2 injuries, with no external contour abnormality and an intimal tear, intraluminal or intramural thrombus, or both, <1 cm in size, with no

to minimal mediastinal hematoma.[29,30] These injuries are associated with a good prognosis and should be considered for nonoperative management with close follow-up as they are known to heal spontaneously.[23] Approximately one-third of MDCT-diagnosed blunt ATAIs are of a minimal grade.[9,18]

Moderate aortic injuries include larger intimal tears, larger intraluminal and intramural thrombus (> 10 mm) or a pseudoaneurysm.[29] An intimal flap or thrombus > 1 cm in size is important in differentiating minimal from moderate aortic injuries as half of intimal flaps > 1 cm are known to progress to a higher injury grade within 8 weeks, at which point they will require repair.[9,17] Endovascular repair or surgery is standard for definitive treatment in this category of patients and its timing depends on the hemodynamic stability of the patient.[31] Severe aortic injuries include active-contrast extravasation or a left subclavian artery hematoma > 15 mm and should be repaired immediately.[29]

MANAGEMENT

Conservative

Treatment of all patients with ATAI begins with anti-impulse therapy (beta-blockers), antiplatelets, and anticoagulant agents.[18] The goal is to maintain a mean arterial pressure ≤ 80 mmHg, systolic blood pressure between 100 and 120 mmHg, and a heart rate between 60 and 80 beats/min. To prevent the injury from progressing further, aortic-wall stress should be reduced, unless contraindicated by concurrent injuries such as traumatic brain or spinal cord injuries that may require elevated blood pressures to maintain adequate tissue perfusion. Such measures drastically decrease the chance of rupture to < 2%.[23] Calcium channel blockers or arterial vasodilators are additionally used when further supplementation is required.[9] Medical management is either temporary (for moderate and severe aortic injuries) or definitive (for MAIs).

A follow-up CT scan within 48 to 72 hours is recommended for patients with MAI to establish stability and/or resolve the abnormality. Endovascular repair can be used to treat any progression during follow-up imaging. Heneghan et al.[29] suggested that follow-up imaging is not needed for such patients, whereas Gunn et al.[32] advised follow-up imaging be performed at 1, 3, 6, and 12 months postinjury, with subsequent yearly cardiovascular MRI scans. Surveillance for such patients typically ends when the aorta returns to a normal appearance.[9] Most studies have shown that progression of disease is rare, and has been found to occur

Table 2. Classification of acute traumatic aortic injuries (Harborview classification)

Severity	Minimal	Moderate	Severe
Characteristic	No external contour abnormality Intimal tear or thrombus < 10 mm	External contour abnormality or intimal tear > 10 mm	Active contrast extravasation Left subclavian artery hematoma > 15 mm
Management	No intervention Optional follow-up imaging	Semi-elective repair Stabilization of concomitant injuries Impulse control	Immediate repair Aortic injury takes priority

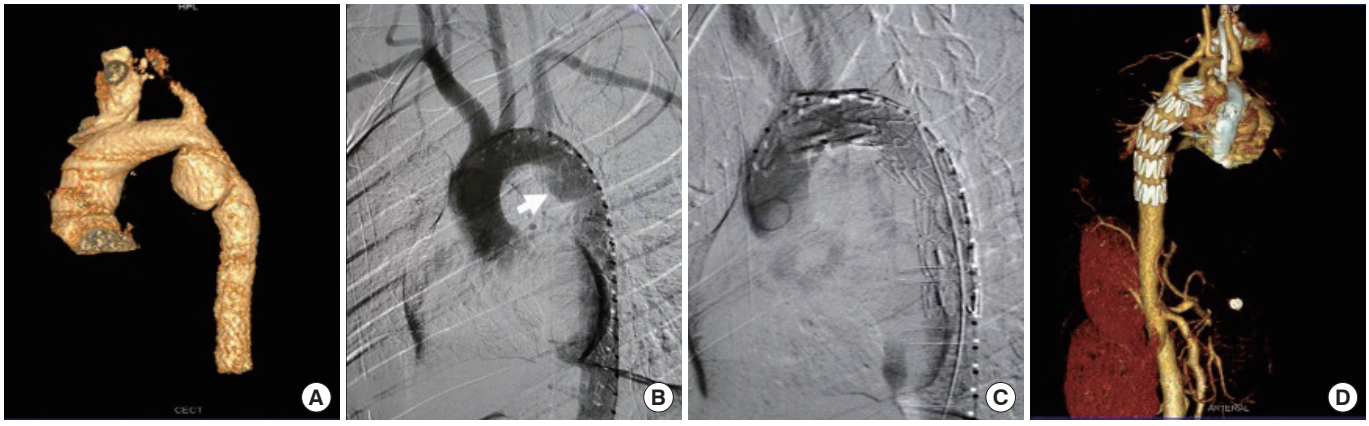

Fig. 11. A pseudoaneurysm in the descending thoracic aorta and its images after stent placement. (A) An multidetector computed tomography volume rendering technique image revealing a pseudoaneurysm in descending thoracic aorta distal to the left subclavian artery with (B) a corresponding aortogram revealing the same (arrow). The patient underwent successful covered stent graft placement, as seen in (C) aortogram, which depicts normal aortic contour poststent placement. (D) A corresponding multidetector computed tomography volume rendering technique images reveal normal aortic contour poststenting.

only in the first month after injury.[9]

Endovascular versus open repair

Endovascular repair (Fig. 11) has gained popularity over open surgical repair, and is now the first line of treatment if it is technically feasible.[24,33] The morbidity associated with a thoracotomy, aortic cross-clamping, and cardiopulmonary bypasses can be avoided with endovascular repair.[8,34] Endovascular repair prevents further progression of ATAI by excluding the aorta from systemic blood pressure. Citing lower risks of morbidity, mortality (9% vs. 19%), and spinal cord ischemia (3% vs. 9%), SVS clinical practice guidelines recommend endovascular repair over open repair for all age groups with suitable anatomy.[35] Patients undergoing endovascular repair have been found to experience reduced complications and earlier hospital discharge compared with those treated with open repair.[9]

Open repair continues to be required in cases with anatomic variations that are incompatible with an endovascular approach. Such variants involve arch type, tortuosity, the diameter of proximal landing zone, and iliac vessel size.[23] Open repairs last longer than endovascular repairs and require less re-intervention; however, their early morbidity and mortality is considerably higher.[21]
Cases of ATAI in abdomen are localized into one of three anatomical zones that determine whether endovascular repair is possible: zone I (diaphragmatic hiatus to superior mesenteric artery [SMA]), zone II (SMA through the renal arteries) and zone III (renal arteries to the aortic bifurcation).[36] Zone I injuries require extensive open exposure, but could be amenable to endovascular repair.[37,38] Zone II injuries are not amenable to endovascular stent placement, as fenestrated grafts customized to accommodate the SMA and renal arteries are not well suited for use in acute settings. Zone III injuries are amenable to open or endovascular repair.[39] Bowel injury must be ruled out to avoid infection of open grafts because of the intraperitoneal free succus or stool. Such scenarios can be managed with endovascular repair.

Timing of repairs

Severe aortic injuries require immediate repair, while repair of moderate aortic injuries is undertaken after management of accompanying injuries and patient stabilization before aortic intervention, which may account for improved outcomes.[23] A study comparing patients who underwent early (< 24 hours) repair compared to delayed (> 24 hours) repair concluded that mortality was remarkably reduced in the patients with delayed repair in comparison to the early repair group (5.8% vs. 16.5%) for this reason.[27]

MANAGEMENT ALGORITHM

Technical aspects

The following must be documented on MDCT for planning of endovascular stent grafting.

Type of injury

The length of the vascular injury and diameter of the aorta cranial and caudal to the site of injury on sagittal oblique multiplanar reformations or curved reformatted images should be documented. Overestimation of stent size by at least 15% is essential to prevent endovascular stent leakage. This is a potential problem, particularly in hypovolemic patients, as underestimates of endoprosthesis caliber may occur because of vasoconstriction in hemorrhagic shock, leading to small aortic caliber.[24,40] Details regarding the proximal and distal landing zone with specific information regarding landing zone length, which should be at least 2 cm, are crucial landing zone calcification if present should also be documented.

Distance from left subclavian artery to the injury

This needs to be measured as a left subclavian artery origin should be covered with a subsequent left carotid-subclavian artery bypass in cases with a small proximal landing zone. An angiography of the aortic arch branches therefore becomes indispensable in assessing circulation in the circle of Willis, particularly before the intentional occlusion of the left subclavian artery, without prior stenting.[18] Prophylactic embolization of the proximal left subclavian artery can be delayed in zone 2 thoracic endovascular aortic repair (TEVAR) due to ATAI, unlike TEVAR performed for an aneurysm. This is because ATAI is an emergency requiring prompt TEVAR, whereas subclavian artery embolization is a preventative procedure to prevent type II endoleakage.[38] These procedural details in traumatic zone II TEVAR are also confirmed in Figs. 5B, C and 11C, D.

Anatomic variants such as arch anatomy (type I, II, III), direct vertebral artery origin and aberrant subclavian artery (e.g., occlusion of aberrant right subclavian artery) have to be determined prior to endoprosthesis placement in the descending thoracic aorta.[14] Other important elements include vertebral artery dominance[14] and tortuosity of the aorta. Existence of atherosclerotic disease or stenosis and prior operative changes, such as a coronary artery bypass graft, should also be noted.

External and common iliac artery diameters and tortuosity

Reduced diameter of access vessels may dramatically alter the appropriate approach to endovascular repair. An iliac artery di-

ameter <7 mm has been considered a limiting factor.[23] A tortuous course of the iliac-femoral axis has not been considered a contraindication of aortic stenting.

Treatment and outcomes of traumatic aortic injuries in younger populations can be problematic because of the smaller aortic caliber, which can complicate graft sizing.[41] Aortic arch geometry is more pointed in younger patients and may have poor compliance of the endograft to the aortic arch.[9]

Monitoring

Minimal aortic injuries should be closely monitored by CTA after 48 to 72 hours and later on as already described. Angiography with MRI has been recommended for further follow-up.

Patients who undergo endovascular repair should also undergo graft surveillance. This is particularly important in younger patients to ensure endograft stability and integrity because the aorta remodels and lengthens with age. Aortic dilatation is more pronounced at the site of implantation and in patients receiving a stent for traumatic injury repair compared with aneurysm repair. Radiological surveillance has been recommended to be performed at 1 and 6 months, annually for the first 5 years, and then every 2 to 3 years on case-by-case basis.[8] A CTA should be used for initial examinations, and MRI can be utilized for follow-up examinations.[8]

CONCLUSION

ATAI is a potentially lethal entity, the outcome of which is highly dependent on early clinical suspicion, radiologic diagnosis of aortic injury, and appropriate management, including endovascular repairs. Radiologists and emergency physicians require access to direct MDCT findings based on the grading and management of aortic injuries chosen and evaluate concomitant visceral injuries that may be more life-threatening than the aortic injury itself.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Original Article

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A quick Sequential Organ Failure Assessment–negative result at triage is associated with low compliance with sepsis bundles: a retrospective analysis of a multicenter prospective registry

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Objective We investigated the effects of a quick Sequential Organ Failure Assessment (qSOFA)–negative result (qSOFA score <2 points) at triage on the compliance with sepsis bundles among patients with sepsis who presented to the emergency department (ED).

Methods Prospective sepsis registry data from 11 urban tertiary hospital EDs between October 2015 and April 2018 were retrospectively reviewed. Patients who met the Third International Consensus Definitions for Sepsis and Septic Shock criteria were included. Primary exposure was defined as a qSOFA score ≥2 points at ED triage. The primary outcome was defined as 3-hour bundle compliance, including lactate measurement, blood culture, broad-spectrum antibiotics administration, and 30 mL/kg crystalloid administration. Multivariate logistic regression analysis to predict 3-hour bundle compliance was performed.

Results Among the 2,250 patients enrolled in the registry, 2,087 fulfilled the sepsis criteria. Only 31.4% (656/2,087) of the sepsis patients had qSOFA scores ≥2 points at triage. Patients with qSOFA scores <2 points had lower lactate levels, lower SOFA scores, and a lower 28-day mortality rate. Rates of compliance with lactate measurement (adjusted odds ratio [aOR], 0.47; 95% confidence interval [CI], 0.29–0.75), antibiotics administration (aOR, 0.64; 95% CI, 0.52–0.78), and 30 mL/kg crystalloid administration (aOR, 0.62; 95% CI, 0.49–0.77) within 3 hours from triage were significantly lower in patients with qSOFA scores <2 points. However, the rate of compliance with blood culture within 3 hours from triage (aOR, 1.66; 95% CI, 1.33–2.08) was higher in patients with qSOFA scores <2 points.

Conclusion A qSOFA-negative result at ED triage is associated with low compliance with lactate measurement, broad-spectrum antibiotics administration, and 30 mL/kg crystalloid administration within 3 hours in sepsis patients.

Keywords Sepsis; Sequential Organ Failure Assessment score; Compliance

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CEEM

Capsule Summary

What is already known

The third international consensus guideline recommended the quick Sequential Organ Failure Assessment (qSOFA) score as a bedside screening tool for sepsis. However, the revised Surviving Sepsis Campaign guideline in 2021 recommends against using qSOFA as a single screening tool for sepsis or septic shock.

What is new in the current study

A qSOFA-negative at emergency department triage is associated with low compliance with lactate measurement, broad-spectrum antibiotics administration, and 30 mL/kg crystalloid administration within 3 hours in sepsis patients.

INTRODUCTION

The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3) defines sepsis as a kind of life-threatening organ dysfunction caused by a dysregulated host response to infection.[1] This guideline also recommends the use of the quick Sequential Organ Failure Assessment (qSOFA) score as a simple bedside screening tool for sepsis outside intensive care units.[2] The qSOFA includes a systolic blood pressure (BP) of ≤ 100 mmHg, a respiratory rate of ≥ 22 breaths/min, and altered mentation, and a qSOFA score of ≥ 2 points is considered a positive result. Although the qSOFA score can be easily and reliably obtained during emergency department (ED) triage, many studies have reported concerns about the low sensitivity of qSOFA at triage for mortality prediction.[3-9]

Sepsis is a medical emergency for which immediate recognition and resuscitation are critical for patient survival.[10] As such, the low sensitivity of qSOFA may lead to a delay in its diagnosis, which may in turn cause a delay in timely treatment. However, to the best of our knowledge, no study has reported delayed resuscitation associated with a qSOFA-negative result in sepsis patients. The hypothesis of this study was that compliance with sepsis bundle management may be delayed in patients with a qSOFA-negative result at triage.[11] As such, we evaluated the association between a qSOFA-negative result at triage and the delay in resuscitation efforts in ED sepsis patients.

METHODS

Design and setting

This study was a retrospective analysis using the multicenter prospective registry of the Korean Shock Society (KoSS). The KoSS registry was designed to evaluate the clinical characteristics, therapeutic interventions, and outcomes of ED patients with septic shock based on the sepsis definition of the 2012 Surviving Sepsis Campaign guideline and the 1991 consensus conference definition of the American College of Chest Physicians and the Society of Critical Care Medicine.[11-13] Eleven EDs participated in the KoSS registry from October 2015 to April 2018. The criteria for inclusion of patients in the KoSS registry were as follows: age of ≥ 19 years, directly visited participating EDs during the study period, diagnosed as having septic shock ≤ 6 hours after arrival, agreed to participate, had no advanced directives, and was not transferred to another facility.

Septic shock is defined by having a suspected or confirmed infection and evidence of refractory hypotension (persistent hypotension after intravenous fluid challenge) or hypoperfusion (hyperlactatemia).[14] However, systemic inflammatory response syndrome criteria were not obligatory for enrollment. Since the registry was opened before the announcement of the new definition, not all patients in this study fulfilled the new Sepsis-3 definition of septic shock. We decided to include all patients who fulfilled the Sepsis-3 definition of sepsis. As such, we excluded patients with missing triage vital signs essential to calculate the qSOFA score, with missing 28-day survival data, and with a SOFA score < 2 points, as these conditions do not comply with the Sepsis-3 definition.

Participation in the KoSS registry was approved by the institutional review boards (IRBs) of the individual participating hospitals, and informed consent was obtained according to the Seoul National University Hospital IRB policy (No. 1408-003-599). This retrospective analysis was also approved by the IRB of Seoul National University Hospital (No. 2012-062-1179).

Data collection

All KoSS registry data were collected using standardized web-based report forms offered by the research coordinators or physicians at each participating hospital. Among the 200 variables in

the KoSS registry, the following data were relevant to this study: demographic characteristics (age and sex), predisposing factors (hypertension and diabetes mellitus), anatomic site of infection (respiratory, hepatobiliary, urinary, gastrointestinal, soft tissue, bone, and joint, mixed, other, or undetermined), vital signs (systolic BP, diastolic BP, heart rate, and body temperature) at triage and enrollment, mental status at triage and enrollment, time variables (triage time and enrollment time), severity measures (initial lactate and SOFA score), outcomes (ED length of stay, outside intensive care unit admission, mechanical ventilation, renal replacement therapy, and 28-day mortality), and 3-hour bundle components (lactate measurement, blood culture, antibiotics administration, and 30 mL/kg crystalloid administration). The time point when the patient was suspected of having sepsis by the physician was defined as the enrollment time. The specific time when each bundle component was delivered, except for crystalloid administration, was recorded in the registry. Fluid resuscitation was coded as whether 30 mL/kg of crystalloid was administered within 3 or 6 hours from triage.

Primary exposure was defined as a qSOFA score ≥2 points at ED triage. Four 3-hour bundle components were selected as the primary outcomes because the KoSS data were collected before the 2018 Update of Surviving Sepsis Campaign Bundle, which recommended a 1-hour bundle.[15]

Statistical analysis

Continuous variables were expressed as medians with interquartile ranges and categorical variables were expressed as percentages. The Wilcoxon rank-sum test was used to compare the continuous variables, and the chi-squared test was used to compare categorical variables between the two groups. The Wilcoxon signed-rank test was also used to compare continuous variables within the paired observations. A histogram using a density scale for the vertical axis with a kernel density curve added was used to visualize the temporal data distribution. A multivariate logistic regression analysis including age, sex, site of infection, and qSOFA score was constructed to predict each bundle component.

Two-tailed P-values <0.05 were considered to be statistically significant. All analyses were performed using either Stata ver. 14.2 (Stata Corp., College Station, TX, USA) or R Statistics (R Foundation for Statistical Computing, Vienna, Austria; http://CRAN.R-project.org).

RESULTS

Population and baseline characteristics

Among the 2,250 patients enrolled in the KoSS registry, 2,087 were included in our analysis following the exclusion of patients with missing data on primary exposure (n=2) and mortality outcomes (n=124) or with SOFA scores <2 points (n=37) (Fig. 1). Patients with qSOFA scores ≥2 points at triage totaled only 31.4% (656/2,087) of the study population.

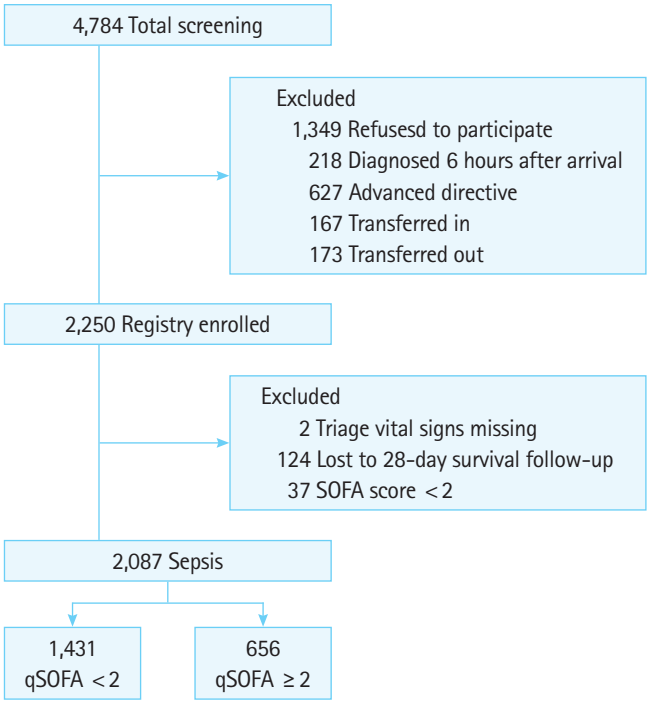

Fig. 1. Patient-selection flowchart. SOFA, Sequential Organ Failure Assessment; qSOFA, quick Sequential Organ Failure Assessment.

The clinical characteristics of enrolled patients according to their qSOFA scores at triage are described in Table 1. Patients with qSOFA scores <2 points at triage were younger and had respiratory infections less frequently. Patients with qSOFA scores <2 points had higher BPs, lower heart rates, lower respiratory rates, and higher body temperatures at triage than patients with qSOFA scores ≥2 points. All qSOFA components were observed less frequently in patients with qSOFA scores <2 points. The time from triage to registry enrollment was longer among patients with qSOFA scores <2 points. Patients with qSOFA scores <2 points had higher BPs, lower heart rates, lower respiratory rates, and higher body temperatures at enrollment as well. Patients with qSOFA scores ≥2 points had higher initial lactate levels and SOFA scores. Patients with qSOFA scores ≥2 points also had a higher 28-day mortality rate (33.4% vs. 16.3%, P<0.001).

Bundle compliance rates

The temporal distributions of enrollment, lactate measurements, blood cultures, and antibiotics administration are visualized in Fig. 2. The times from triage to enrollment, lactate measurement,

Table 1. Clinical characteristics of sepsis patients according to qSOFA score at triage (n=2,087)

Characteristic	qSOFA <2 (n=1,431)	qSOFA ≥2 (n=656)	P-value
Demographics			
Age (yr)	69 (59–77)	71 (62–78.5)	0.005
Male sex	840 (58.7)	385 (58.7)	0.996
Predisposing factors			
Diabetes mellitus	433 (30.3)	205 (31.3)	0.648
Hypertension	580 (40.5)	280 (42.7)	0.354
Anatomic site of infection			<0.001
Respiratory	302 (21.1)	217 (33.1)	
Hepatobiliary	313 (21.9)	77 (11.7)	
Urinary	265 (18.5)	110 (16.8)	
Gastrointestinal	197 (13.8)	72 (11.0)	
Soft tissue, bone, and joint	44 (3.1)	14 (2.1)	
Mixed	149 (10.4)	96 (14.6)	
Other	77 (5.4)	30 (4.6)	
Undetermined	84 (5.9)	40 (6.1)	
Vital signs at triage			
Systolic BP (mmHg)	99 (82–122)	84 (72–97)	<0.001
Diastolic BP (mmHg)	59 (50–72)	52 (44–61)	<0.001
Heart rate (/min)	106 (90–124)	115 (97–130)	<0.001
Respiratory rate (/min)	20 (18–20)	24 (22–28)	<0.001
Body temperature (°C)	37.7 (36.8–38.7)	37.5 (36.5–38.4)	<0.001
Fever (body temperature ≥38°C)	624 (43.6)	243 (37.0)	0.005
qSOFA component at triage			
Systolic BP ≤100 mmHg	741 (51.8)	542 (82.6)	<0.001
Respiratory rate ≥22/min	279 (19.5)	528 (80.5)	<0.001
Altered mental status	74 (5.2)	372 (56.7)	<0.001
qSOFA score at triage (point)			-
0	337 (23.5)	0	
1	1094 (76.5)	0	
2	0	526 (80.2)	
3	0	130 (19.8)	
Time from triage to enrollment (min)	65.5 (19.7–131.1)	26.2 (4.4–76.5)	<0.001
Vital signs at enrollment			
Systolic BP (mmHg)	86 (78–99)	82 (72–91)	<0.001
Diastolic BP (mmHg)	52 (46–60)	50 (43–58)	<0.001
Heart rate (/min)	102 (88–118)	110 (95–127)	<0.001
Respiratory rate (/min)	20 (18–23)	22 (20–27)	<0.001
Body temperature (°C)	37.5 (36.8–38.3)	37.3 (36.5–38.1)	<0.001
qSOFA components at enrollment			
Systolic BP ≤100 mmHg	1095 (76.5)	572 (87.2)	<0.001
Respiratory rate ≥22/min	457 (31.9)	395 (60.2)	<0.001
Altered mental status	103 (7.2)	340 (51.8)	<0.001
qSOFA score at enrollment (point)			<0.001
0	139 (9.7)	11 (1.7)	
1	956 (66.8)	119 (18.1)	
2	309 (21.6)	390 (59.5)	
3	27 (1.9)	136 (20.7)	
Severity measures			
Initial lactate (mmol/L)[a]	3.1 (1.8–5.0)	4.0 (2.2–6.5)	<0.001
SOFA score	7 (5–10)	10 (7–12)	<0.001

(*Continued to the next page*)

Table 1. Continued

Characteristic	qSOFA < 2 (n = 1,431)	qSOFA ≥ 2 (n = 656)	P-value
Outcomes			
ED length of stay (hr)	8.6 (5.3–18.4)	6.4 (4.0–11.9)	< 0.001
ICU admission	838 (58.6)	481 (73.3)	< 0.001
Mechanical ventilation	317 (22.2)	277 (42.2)	< 0.001
Renal replacement therapy	170 (11.9)	143 (21.8)	< 0.001
28-Day mortality	233 (16.3)	219 (33.4)	< 0.001

Values are presented as median (interquartile range) or number (%). Continuous variables were compared by the Wilcoxon rank-sum test and categorical variables were compared by the chi-squared test.
qSOFA, quick Sequential Organ Failure Assessment; BP, blood pressure; SOFA, Sequential Organ Failure Assessment; ED, emergency department; ICU, intensive care unit.
[a]Patients without lactate measurement were excluded (n = 27).

Table 2. Bundle compliances of sepsis patients according to qSOFA scores at triage (n=2,087)

Bundle component	qSOFA scores < 2 points (n = 1,431)	qSOFA scores ≥ 2 points (n = 656)	P-value
Lactate measurement			
Time from triage (min)[a]	30.6 (15.3–63.4)	19.7 (10.9–37.1)	< 0.001
Within 1 hour from triage	1,034 (72.3)	557 (84.9)	< 0.001
Within 3 hours from triage	1,324 (92.5)	634 (96.7)	< 0.001
Blood culture			
Time from triage (min)[a]	59.0 (24.0–137.6)	77.6 (26.2–187.9)	0.002
Within 1 hour from triage	718 (50.2)	285 (43.5)	0.004
Within 3 hours from triage	1,173 (82.0)	476 (72.6)	< 0.001
Antibiotics administration			
Time from triage (min)[a]	143.2 (91.8–220.6)	118.0 (69.9–181.3)	< 0.001
Within 1 hour from triage	178 (12.4)	131 (20.0)	< 0.001
Within 3 hours from triage	905 (63.2)	482 (73.5)	< 0.001
Prior to blood culture	238 (16.6)	204 (31.1)	< 0.001
30 mL/kg of crystalloid administration			
Within 3 hours from triage	990 (69.2)	509 (77.6)	< 0.001
Within 3 hours from triage for hypotension or lactate ≥ 4 mmol/L[b]	903 (70.5)	489 (78.1)	< 0.001

Values are presented as median (interquartile range) or number (%). Continuous variables were compared by the Wilcoxon rank-sum test and categorical variables were compared by the chi-squared test.
qSOFA, quick Sequential Organ Failure Assessment.
[a]Patients without lactate measurement (n = 27), blood culture (n = 9), and antibiotics administration (n = 18) were excluded from each analysis. [b]Only patients with hypotension or lactate ≥ 4 mmol/L (n = 1,281 for qSOFA scores < 2 points and n = 626 for qSOFA scores ≥ 2 points) were analyzed.

and administration of antibiotics, respectively, were shorter among patients with qSOFA scores ≥ 2 points, while the time to blood culture was shorter among patients with qSOFA scores < 2 points.

The bundle compliance profile according to qSOFA scores at triage is described in Table 2. Rates of sepsis bundle compliance with lactate measurement (92.5% vs. 96.7%), antibiotics administration (63.2% vs. 73.5%), and 30 mL/kg crystalloid administration (70.5% vs. 78.1%) within 3 hours from triage were significantly lower in patients with qSOFA scores < 2 points. However, the rate of compliance with blood culture within 3 hours from triage (82.0% vs. 72.6%) was higher in patients with qSOFA scores < 2 points. Also, 31.1% of patients with qSOFA scores ≥ 2 points received antibiotics prior to blood culture, which was significantly higher than the 16.6% of patients with qSOFA scores < 2 points who did (Table 2).

Multivariate logistic regression showed a qSOFA-negative result was independently associated with lower compliance with lactate measurement (adjusted odds ratio [aOR], 0.47; 95% confidence interval [CI], 0.29–0.75), antibiotics administration (aOR, 0.64; 95% CI, 0.52–0.78), and 30 mL/kg crystalloid administration (aOR, 0.62; 95% CI, 0.49–0.77) within 3 hours from triage (Table 3). Also, compliance with blood culture within 3 hours from triage was significantly higher among patients with qSOFA-negative results (aOR, 1.66; 95% CI, 1.33–2.08; P < 0.001).

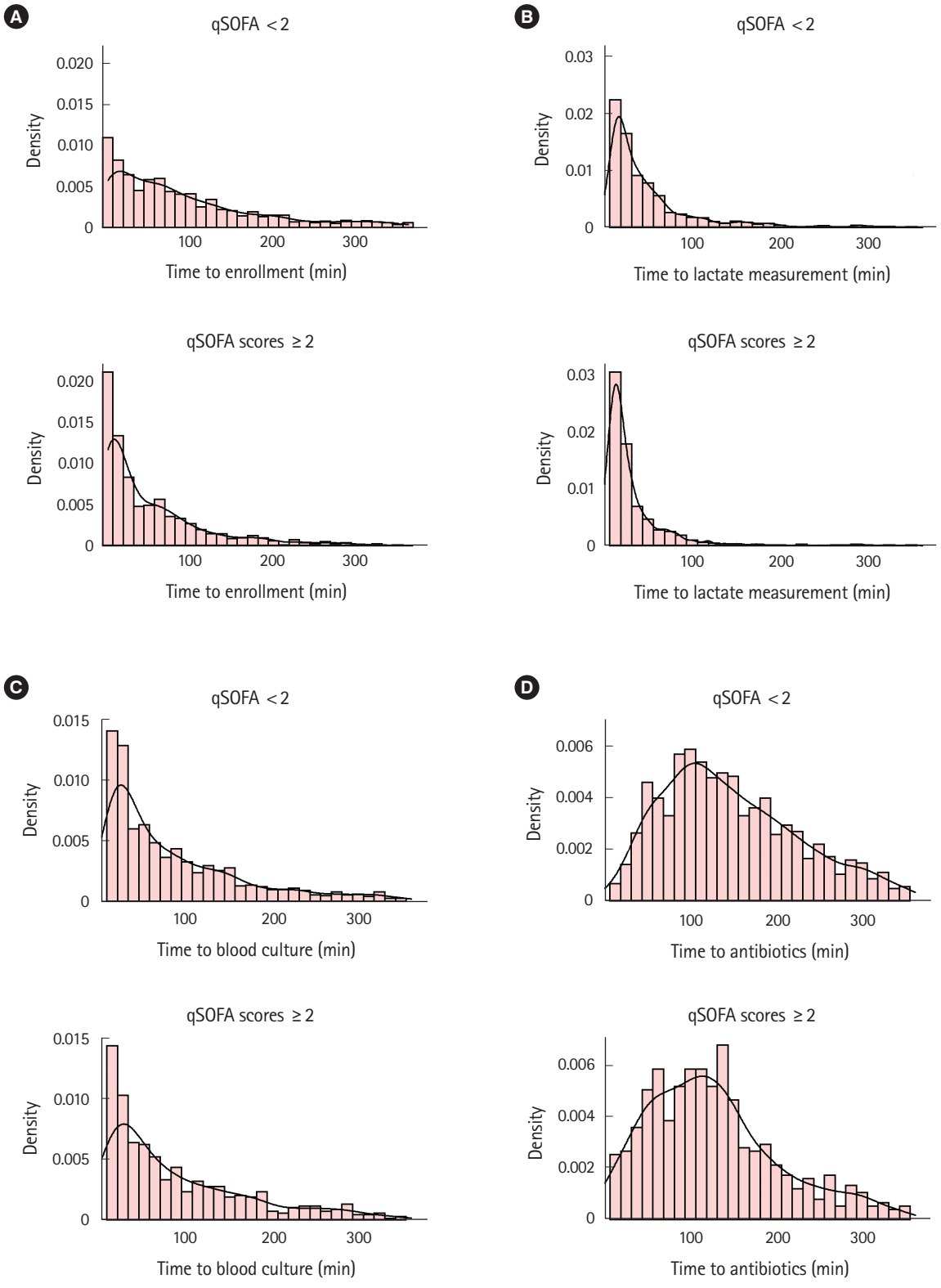

Fig. 2. Histogram using a density scale for the vertical axis and adding a kernel density curve to visualize the temporal distributions of each time variable between patients with quick Sequential Organ Failure Assessment (qSOFA) scores <2 points and qSOFA scores ≥2 points. Time to (A) enrollment, (B) lactate measurement, (C) blood culture, and (D) antibiotics.

Table 3. Adjusted odds ratio of a qSOFA-negative result for predicting compliance with each bundle component (n=2,087)[a]

Variable	aOR (95% CI)	P-value
Lactate measurement within 3 hours from triage	0.47 (0.29–0.75)	0.002
Blood culture within 3 hours from triage	1.66 (1.33–2.08)	<0.001
Antibiotics administration within 3 hours from triage	0.64 (0.52–0.78)	<0.001
30 mL/kg of crystalloid administration within 3 hours from triage	0.62 (0.49–0.77)	<0.001

aOR, adjusted odds ratio; qSOFA, quick Sequential Organ Failure Assessment; CI, confidence interval.
[a]Multivariate logistic regression analysis included age, sex, and anatomic site of infection as confounding factors.

DISCUSSION

In this study, we found that a qSOFA-negative result at ED triage is associated with low compliance with lactate measurement, broad-spectrum antibiotics administration, and 30 mL/kg crystalloid administration within 3 hours in sepsis patients.

Singer et al.[1] recommended that clinicians monitor clinical conditions, reevaluate patients for possible sepsis, and calculate full SOFA scores for those patients with suspected infection and an initial qSOFA-negative result. Additionally, they emphasized that failure to attain a qSOFA score of ≥ 2 points should not lead to a delay in any other care aspects. However, in this study, sepsis patients with qSOFA-negative results (qSOFA score < 2 points) at triage were subsequently recognized as having sepsis and later received the resuscitation bundle, composed of lactate measurement, antibiotics administration, and 30 mL/kg crystalloid administration less frequently and later than patients with a qSOFA of 2 or greater.

Sepsis is a medical emergency in which early identification and appropriate immediate management improve outcomes.[16,17] Therefore, the 2018 update of the Surviving Sepsis Campaign recommended that all 3- and 6-hour bundles be initiated even within 1 hour.[15] Assuming sepsis was recognized and the participating clinicians decided to include the patient in the KoSS registry, then patients with qSOFA-negative results at triage required a median of 65 minutes to be recognized as having sepsis. Lactate measurement, antibiotics administration, and 30 mL/kg crystalloid administration were significantly delayed in patients with qSOFA-negative results, while blood culture was performed earlier for these patients. There are several possible explanations for this difference. First, patients with fever (initial body temperature ≥ 38°C) are more likely to receive a blood culture test early, and patients with qSOFA-negative results had fever more frequently (624/1,431 [43.6%] vs. 243/656 [37.0%], P = 0.005) (Table 1). Among patients with fever, the time to blood culture was similar between patients with qSOFA scores < 2 points (45.9 minutes) and those with qSOFA scores ≥ 2 points (48.1 minutes, P = 0.193) (Supplementary Table 1). However, the time to blood culture was significantly delayed in patients without fever (85.2 vs. 45.9 minutes, P < 0.001). Furthermore, among patients without fever, the time to blood culture was delayed more in patients with qSOFA-positive results (102.7 vs. 76.5 minutes, P < 0.001). We think that this delay is due to the lack of priority of blood culture tests for treatments required to maintain hemodynamic stability in these critically ill patients. The Surviving Sepsis Campaign recommended that the administration of appropriate antibiotic therapy should not be delayed in order to obtain blood cultures.[15] In this study, patients with qSOFA scores ≥ 2 points apparently had a greater severity, which led to early initiation of life-saving treatments such as lactate measurements, antibiotics administration, and fluid boluses. Blood culture tests may have been delayed due to these treatments, especially in EDs with limited resources. As mentioned in the results section, the fact that more patients with qSOFA scores ≥ 2 points received antibiotics prior to blood culture also supports this opinion.

We have shown that qSOFA-negative results were associated with delayed resuscitative measures. More importantly, patients with qSOFA-negative results at triage accounted for 68.6% of the sepsis cases in this study. Additionally, more than half of the sepsis patients with mortality (233/452, 51.5%) had qSOFA scores < 2 points at triage. Many studies performed in an ED setting consistently reported a low prevalence of patients with qSOFA-positive results for sepsis.[3-9] Although the severity of patients with qSOFA-negative results was lower than of patients with qSOFA-positive results, the 28-day mortality rate of these patients was as high as 16.3% in this study.

If a considerable number of sepsis patients have qSOFA-negative results at initial presentation, which is associated with delayed recognition and treatment delivery, an additional screening tool should be considered. The repeated assessment of the qSOFA score may be an alternative. Kievlan et al.[18] reported using in-hospital mortality data that repeated qSOFA measurements improve predictive validity for sepsis compared to a single qSOFA measurement. However, they used repeated qSOFA measurements performed over 48 hours, which is not appropriate in emergency situations. In this study, only 23.5% of patients with qSO-

FA-negative results at triage had qSOFA scores ≥ 2 points at enrollment. Seymour et al.[2] reported that the addition of serum lactate levels significantly improved the predictive validity of qSOFA and had a discriminative ability for in-hospital mortality in patients with a qSOFA score of 1 point. A previous study[8] also reported that adding lactate ≥ 2 mmol/L significantly increased sensitivity (61.9% vs. 90.9%) of qSOFA for 28-day mortality. Ho and Lan[19] reported that this approach could have a higher predictive ability comparable to that of the standard SOFA score. We contend that emergency physicians should be aware that the qSOFA score derived from triage vital signs is not sensitive enough to identify patients at high risk for in-hospital mortality and suggest the measurement of serum lactate levels in patients with suspected infection to determine whether early resuscitation is warranted.[20]

Our study had several limitations. Data from a multicenter prospective registry were analyzed in this study. However, a considerable number of patients were not enrolled in the chosen registry because written informed consent was required by the local IRB policy. Those patients who refused to participate might have had different clinical characteristics. Furthermore, the KoSS registry was intended to include patients with septic shock. Although we enrolled patients who fulfilled the new definition of Sepsis-3, those patients enrolled in this study may have a higher severity than general ED patients with sepsis, and we may have included more patients with the qSOFA component of hypotension. However, sepsis patients with greater disease severity and likelihood of hypotension are more likely to benefit from bundle therapy. When we analyzed patients who met the septic shock criteria of Sepsis-3, the results were similar to those of this study. Finally, the purpose of this study was to confirm that a qSOFA-negative result was associated with a delay in bundle therapy, not to confirm the effects of such a delay on mortality. All components of the bundles are not equally effective and not supported by solid evidence.[21] However, this issue is beyond the scope of this paper.

In conclusion, we found that a qSOFA-negative result at ED triage is associated with low compliance with lactate measurement, broad-spectrum antibiotics administration, and 30 mL/kg crystalloid administration within 3 hours for sepsis patients.

SUPPLEMENTARY MATERIAL

Supplementary Table 1. Time from triage to blood culture according to fever and qSOFA score at triage

Supplementary material is available from: https://doi.org/10.15441/ceem.22.230.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Original Article

Association of transport time interval with neurologic outcome in out-of-hospital cardiac arrest patients without return of spontaneous circulation on scene and the interaction effect according to prehospital airway management

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Objective This study analyzed the association of transport time interval (TTI) with survival rate and neurologic outcome in out-of-hospital cardiac arrest (OHCA) patients without return of spontaneous circulation (ROSC) and the interaction effect of TTI according to prehospital airway management.

Methods A retrospective observational study based on the nationwide OHCA database from January 2013 to December 2017 was designed. Emergency medical service (EMS)-treated OHCA patients aged ≥ 18 years were included. TTI was categorized into four groups of quartiles (≤ 4, 5–7, 8–11, ≥ 12 minutes). The primary outcome was favorable neurologic outcome at discharge. The secondary outcome was survival to discharge from the hospital. Multivariable logistic regression was used to analyze outcomes according to TTI. A different effect of TTI according to the administration of prehospital EMS advanced airway was evaluated.

Results In total, 83,470 patients were analyzed. Good neurologic recovery decreased as TTI increased (1.0% for TTI ≤ 4 minutes, 0.9% for TTI 5–7 minutes, 0.6% for TTI 8–11 minutes, and 0.5% for TTI ≥ 12 minutes; P for trend < 0.05). The adjusted odds ratio of prolonged TTI (≥ 12 minutes) was 0.73 (95% confidence interval, 0.57–0.93; P < 0.01) for good neurologic recovery. However, the negative effect of prolonged TTI on neurological outcome was insignificant when advanced airway or entotracheal intubation were performed by EMS providers (adjusted odds ratio, 1.17; 95% confidence interval, 0.42–3.29; P = 0.76).

Conclusion EMS TTI was negatively associated with the neurologic outcome of OHCA without ROSC on scene. When advanced airway was performed on scene, TTI was insignificantly associated with the outcome.

Keywords Heart arrest; Emergency medical services; Intubation

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Capsule Summary

What is already known

In out-of-hospital cardiac arrest, patients that do not respond to field emergency medical service management should be transported to a hospital for advanced cardiac arrest care.

What is new in the current study

When no return of spontaneous circulation is achieved at the scene of an out-of-hospital cardiac arrest after emergency medical service management, minimizing hospital transport time is important for patient outcome. However, if transport time is suspected to be delayed, an advanced airway might be beneficial in good neurological outcome.

INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) remains a primary public health problem because of the low survival rate and the unfavorable neurologic outcome.[1-3] Both prehospital resuscitation and hospital-based post-cardiac arrest care are emphasized to be important components in the chain of survival.[4,5] Emergency medical services (EMS) dispatched to the OHCA scene, perform prehospital management, including high-quality compression and airway management, and determine the mode for transporting the patient to the emergency medical center for adequate post-cardiac arrest treatment.[6,7]

The time for transporting the patient from on-scene departure to arrival at the emergency department (ED) is defined as the transport time interval (TTI).[8-12] Previous studies have shown that TTI does not have any significant effect on the survival outcome.[8,9,11] However, these studies were mainly conducted under a system wherein most patients were treated with the advanced cardiac life support (ACLS) system in the prehospital stage.[8,9,11,13] In an environment where EMS plays a limited role in the termination of resuscitation, OHCA patients without return of spontaneous circulation (ROSC) are transferred to the ED with ongoing resuscitation in the ambulance, which may interrupt high-quality cardiopulmonary resuscitation (CPR) and other interventions.[7,14-16] In addition, there have been no previous studies on the difference in TTI effects according to the interventions performed by the EMS on scene before the transport of the OHCA patient. Therefore, it is necessary to consider the impact of TTI on patient outcome in that OHCA patients without ROSC should be transferred to the center where suitable approaches for management are carried out in the appropriate time.[17]

The present study primarily aimed to evaluate the association of TTI with survival rate and neurologic outcome in OHCA patients without prehospital ROSC on scene. The secondary objective was to evaluate the interaction effect of TTI according to different types of prehospital airway management.

METHODS

Ethics statement

This study was approved by the institutional review board of Seoul National University Hospital (No. 1103–153-357), and the need for informed consent was waived for the present study due to minimal risk.

Study design and setting

This was a retrospective observational study based on the nationwide OHCA registry in Korea. The EMS of Korea is a single-tiered, government-based system. It is operated by 16 provincial headquarters of the National Fire Agency. Emergency medical technicians (EMTs) are divided into two levels: level 1 EMT and level 2 EMT. Level 1 EMTs are compatible with advanced EMTs in the United States, and level 2 EMTs are compatible with EMTs in the United States. Only level 1 EMTs can perform intravenous fluid resuscitation and prehospital airway management such as endotracheal intubation (ETI) or supraglottic airway (SGA), but they are restricted to administer epinephrine or other ACLS drugs during CPR even under direct medical supervision. They are also not allowed to discontinue CPR or declare death without ROSC at the scene. Thus, ACLS is available only in hospitals, which requires all OHCA patients to be transported to the ED regardless of their ROSC status. In the national EMS protocol, the transfer of OHCA patients is recommended to the nearest level 2 or higher EDs. EDs are designated by the government as levels 1 to 3 based on the availability of human resources, intensive care unit, and equipment. Level 1 EDs have the best facilities and resources, but these EDs must be covered by designated board-certified emergency physicians throughout (24 hours) a day.

Database

In 2006, the nationwide EMS-assessed OHCA registry was established by the Ministry of Health and Welfare of Korea. The Korea Centers for Disease Control and Prevention has managed the registry with financial support since 2007. The database consists of data on acute myocardial infarction and acute stroke from OHCA patients nationwide. The data of all OHCA cases assessed by the EMS are collected from the EMS run sheets containing demographic and Utstein information. The EMS run sheets are electronically stored in the server of EMS headquarters after the transportation of OHCA patients. The hospital electronic medical records were then reviewed to assess hospital resuscitation and postresuscitation care. Expert reviewers from the Korea Centers for Disease Control and Prevention visit the hospital where the OHCA patient was transported, and they investigate the medical records of the patient for collecting detailed clinical information and assessing outcomes using a structured survey form.

Study population

All adult OHCA patients who were treated by the EMS between January 2013 and December 2017 were included in the study. Patients were excluded if they were aged < 18 years or if the cause of arrest had a noncardiac origin. Patients who underwent prehospital ROSC by the EMS before hospital transport were excluded. Patients with unknown prehospital ROSC status and those with a TTI of longer than 60 minutes were also excluded.

Variables

The main exposure variable in this study was TTI. TTI was defined as the time between EMS scene departure and hospital arrival. TTI was categorized into four groups according to its distribution (≤ 4, 5–7, 8–11, and ≥12 minutes).

The methods of airway management were classified as ETI, SGA, or bag-valve mask ventilation. The EMT may carry out SGA or ETI at the scene or during the transportation, but only level 1 EMTs can perform ETI. EMTs may determine not to insert an ETI or SGA, thereby using only a bag-valve mask during CPR and transportation, or choose ETI or SGA by their preference or proficiency.

Data of patients' characteristics were obtained from the nationwide registry database. The information included age, sex, community urbanization (metropolitan area or not), arrest location (public, private, or other), witnessed status, bystander CPR, initial EMS rhythm, prehospital defibrillation, EMS response time interval, scene time interval, TTI, EMS advanced airway, EMS intravenous access, and level of EDs (level 1, 2, or 3).

Outcomes

The primary outcome in this study was good neurologic recovery, defined as Glasgow-Pittsburgh cerebral performance category score of 1 or 2 at hospital discharge. The secondary outcome was survival to discharge from the hospital.

Statistical analysis

Demographics, prehospital EMS interventions and outcomes were compared according to the TTI groups. Data of categorical variables were compared using the chi-square test, and data of continuous variables were compared using Student t-test and analysis of variance. We analyzed the association between TTI and neurologic outcome using multivariable logistic regression analysis adjusting for possible confounders such as age, sex, community urbanization, arrest location, witnessed status, bystander CPR, initial EMS rhythm, prehospital defibrillation, EMS response time interval, scene time interval, and EMS intravenous access. In the regression analysis, we divided the patients into two groups by a TTI of 12 minutes: the group with a TTI of more than 12 minutes and the group with a TTI of less than 12 minutes; the odds ratios (ORs) of both groups were calculated and compared. In addition, the OR was calculated when the TTI increased by 1 minute. Interaction analysis was performed to evaluate the different effects of TTI on outcomes according to whether the administration of prehospital advanced airway was performed by the EMS provider. All statistical analyses were performed using SAS ver. 9.4 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Demographics and outcomes according to TTI

In total, 137,268 patients with OHCA identified from the nationwide registry database were evaluated during the study period; 2,872 pediatric OHCA patients were excluded. Among 139,396 adult OHCA patients, we excluded 35,090 patients with noncardiac cause of arrest, 8,554 EMS-treated patients, 521 patients with TTI longer than 60 minutes, and 6,761 patients with prehospital ROSC or unknown ROSC status; finally, 83,470 OHCA patients without prehospital ROSC were enrolled (Fig. 1).

The enrolled patients were classified into four groups according to the TTI distribution. Demographic and patient characteristics are presented in Table 1. Among the total population, the number of patients who survived to discharge was 2,238 (2.7%) and the number of patients who showed a favorable neurological outcome was 636 (0.8%). Moreover, 18,455 patients were identified to have a TTI of more than 12 minutes, in which the rate of the metropolitan area was significantly lower than that in the other

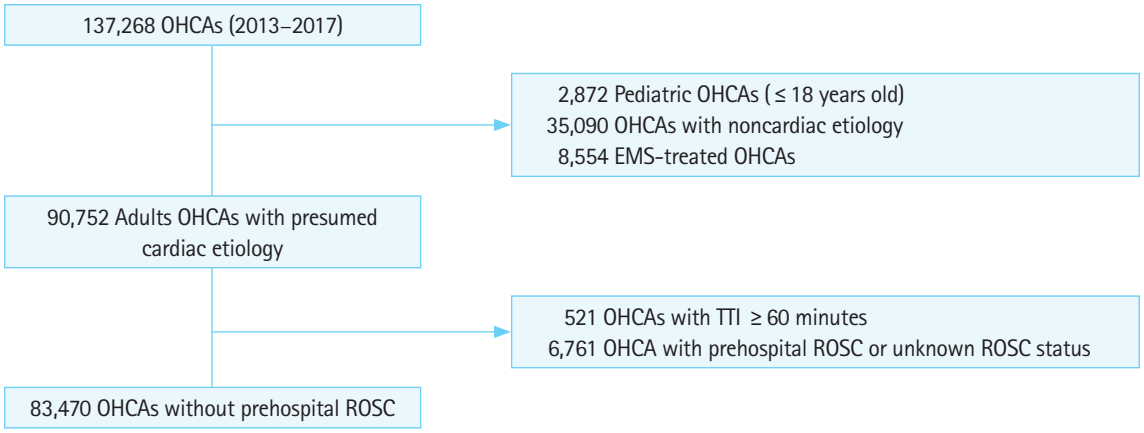

Fig. 1. Selection of the study population for analysis. OHCA, out-of-hospital cardiac arrest; EMS, emergency medical service; TTI, transport time interval; ROSC, return of spontaneous circulation.

Table 1. Characteristics of the study population based on transport time interval

Characteristic	Total (n = 83,470)	≤ 4 min (n = 22,322)	5–7 min (n = 25,357)	8–11 min (n = 17,336)	≥ 12 min (n = 18,455)	P-value
Year						< 0.01
2013	15,641 (18.7)	3,747 (16.8)	4,831 (19.1)	3,345 (19.3)	3,718 (20.1)	
2014	16,723 (20.0)	4,111 (18.4)	5,255 (20.7)	3,565 (20.6)	3,792 (20.5)	
2015	17,529 (21.0)	4,859 (21.8)	5,401 (21.3)	3,598 (20.8)	3,671 (19.9)	
2016	16,851 (20.2)	4,703 (21.1)	5,023 (19.8)	3,499 (20.2)	3,626 (19.6)	
2017	16,726 (20.0)	4,902 (22.0)	4,847 (19.1)	3,329 (19.2)	3,648 (19.8)	
Age (yr)	70.1 ± 15.1	69.8 ± 15.2	69.9 ± 15.2	70.6 ± 15.0	71.3 ± 14.6	< 0.01
Male sex	52,104 (62.4)	13,986 (62.7)	15,785 (62.3)	10,743 (62.0)	11,590 (62.8)	0.32
Time of day						< 0.01
0 a.m.–8 a.m.	21,113 (25.3)	6,041 (27.1)	6,492 (25.6)	4,257 (24.6)	4,323 (23.4)	
8 a.m.–4 p.m.	34,237 (41.0)	9,124 (40.9)	10,313 (40.7)	7,104 (41.0)	7,696 (41.7)	
4 p.m.–0 a.m.	28,120 (33.7)	7,157 (32.1)	8,552 (33.7)	5,975 (34.5)	6,436 (34.9)	
Location (metropolis)	34,624 (41.5)	10,287 (46.1)	13,157 (51.9)	7,492 (43.2)	3,688 (20.0)	< 0.01
Witnessed arrest	37,892 (45.4)	9,587 (42.9)	11,364 (44.8)	8,078 (46.6)	8,863 (48.0)	< 0.01
Initial EMS rhythm (shockable)	9,649 (11.6)	2,605 (11.7)	2,947 (11.6)	1,965 (11.3)	2,132 (11.6)	0.75
EMS defibrillation	15,755 (18.9)	3,840 (17.2)	4,584 (18.1)	3,319 (19.1)	4,012 (21.7)	< 0.01
EMS airway						< 0.01
Bag-valve mask	53,670 (64.3)	13,687 (61.3)	15,583 (61.5)	11,074 (63.9)	13,326 (72.2)	
Endotracheal intubation	4,433 (5.3)	1,277 (5.7)	1,447 (5.7)	865 (5.0)	844 (4.6)	
Supraglottic airway	25,367 (30.4)	7,358 (33.0)	8,327 (32.8)	5,397 (31.1)	4,285 (23.2)	
EMS time interval						
Response time interval (min)	7 (5–10)	6 (5–8)	7 (5–9)	7 (6–10)	10 (6–14)	< 0.01
Scene time interval (min)	11 (7–15)	11 (8–15)	11 (7–15)	10 (7–14)	10 (6–14)	< 0.01
EMS intravenous access	15,430 (18.5)	4,605 (20.6)	5,118 (20.2)	3,169 (18.3)	2,538 (13.8)	< 0.01
Emergency department level						< 0.01
1	11,713 (14.0)	2,841 (12.7)	3,814 (15.0)	2,593 (15.0)	2,465 (13.4)	
2	40,281 (48.3)	10,373 (46.5)	13,263 (52.3)	8,866 (51.1)	7,779 (42.2)	
3	31,476 (37.7)	9,108 (40.8)	8,280 (32.7)	5,877 (33.9)	8,211 (44.5)	
Survival outcome						
Survival to discharge	2,238 (2.7)	718 (3.2)	779 (3.1)	432 (2.5)	309 (1.7)	< 0.01
Good neurological outcome	636 (0.8)	220 (1.0)	219 (0.9)	106 (0.6)	91 (0.5)	< 0.01

Values are presented as number (%), mean ± standard deviation, or median (interquartile range).
EMS, emergency medical service.

Table 2. Association of transport time interval with survival rate and neurologic outcome

Variable	Unadjusted		Adjusted[a]		P-value
	OR	95% CI	OR	95% CI	
Survival to discharge					
TTI ≥ 12 min	0.56	0.49–0.63	0.71	0.61–0.80	< 0.01
TTI 1-min increase	0.96	0.95–0.98	0.98	0.96–0.99	< 0.01
Favorable neurologic outcome					
TTI ≥ 12 min	0.57	0.49–0.63	0.73	0.57–0.93	0.01
TTI 1-min increase	0.97	0.95–0.98	0.98	0.96–0.99	< 0.01

OR, odds ratio; CI, confidence interval; TTI, transport time interval; EMS, emergency medical service.
[a]Adjusted covariables: age, sex, community urbanization, arrest location, witnessed status, bystander cardiopulmonary resuscitation, initial EMS rhythm, prehospital defibrillation, EMS response time interval, scene time interval, EMS advanced airway, and EMS intravenous access.

three groups with a TTI of less than 12 minutes (n = 3,688, 20.0%, P < 0.01). In terms of the rate of advanced airway management, the longer the TTI, the lower the rate observed (38.7% vs. 38.5% vs. 36.1% vs. 27.8%, P < 0.01). The neurological outcome was significantly less favorable in the group with a longer TTI than in the group with a shorter TTI (3.2% vs. 3.1% vs. 2.5% vs. 1.7%, P < 0.01).

Multivariable logistic regression of the association between TTI and patient outcomes

Based on a TTI of less than 12 minutes, the ORs of the survival rate and neurological outcome in the group with a TTI of more than 12 minutes were compared. Using multivariable logistic regression analysis after adjustment for possible confounders, the adjusted OR (aOR) for favorable neurologic outcome was lower when the TTI was more than 12 minutes (0.73; 95% confidence interval [CI], 0.57–0.93; P = 0.01). It was also shown that the aOR when the TTI increased by 1 minute was decreased by 0.98 (95% CI, 0.96–0.99; P < 0.01). The aOR of the survival rate in the group with a TTI of more than 12 minutes was 0.71 (95% CI, 0.61–0.80; P < 0.01) (Table 2).

Interaction effect of prehospital airway management on the association between TTI and patient outcomes

The aOR for a TTI of 12 minutes was compared according to the type of prehospital airway placement. Although the aOR of the favorable neurologic outcome was 0.66 (95% CI, 0.499–0.872; P < 0.01), the aOR was insignificant in the group with a TTI of more than 12 minutes when prehospital advance airway placement was performed (0.98; 95% CI, 0.6–1.50; P = 0.92). When prehospital ETI was performed, the aOR of the neurologic outcome was not significant in the group with a TTI of more than 12 minutes (1.17; 95% CI, 0.42–3.29; P = 0.76). The aOR of the neurologic outcome was not significant, as the TTI increased by 1 minute if prehospital airway placement was performed (aOR of 1.00 for advanced airway; 95% CI, 0.97–1.02; P = 0.77; aOR of 1.01 for ETI; 95% CI, 0.97–1.06; P = 0.57). In the case of survival rate, the significant difference in the aOR according to TTI disappeared when ETI was performed (0.99; 95% CI, 0.58–1.68; P = 0.97) (Table 3).

Table 3. Interaction effect according to the type of prehospital airway placement on transport time interval and survival outcome

Variable	Adjusted OR	95% CI	P-value
Survival to discharge			
TTI ≥ 12 min (vs. TTI < 12 min)			
Advanced airway			
Not performed	0.71	0.61–0.82	< 0.01
Performed	0.73	0.57–0.93	< 0.01
ETI			
Not performed	0.70	0.61–0.80	< 0.01
Performed	0.99	0.58–1.68	0.97
TTI 1-min increase			
Advanced airway			
Not performed	0.99	0.98–0.99	< 0.01
Performed	0.98	0.97–0.99	0.02
ETI			
Not performed	0.98	0.97–0.99	< 0.01
Performed	1.01	0.99–1.03	0.45
Favorable neurologic outcome			
TTI ≥ 12 min (vs. TTI < 12 min)			
Advanced airway			
Not performed	0.66	0.50–0.87	< 0.01
Performed	0.98	0.64–1.50	0.92
ETI			
Not performed	0.72	0.56–0.92	< 0.01
Performed	1.17	0.42–3.29	0.76
TTI 1-min increase			
Advanced airway			
Not performed	0.97	0.96–0.99	< 0.01
Performed	1.00	0.97–1.02	0.77
ETI			
Not performed	0.98	0.96–0.99	< 0.01
Performed	1.01	0.97–1.06	0.57

OR, odds ratio; CI, confidence interval; TTI, transport time interval; ETI, endotracheal intubation; EMS, emergency medical service.
[a]Adjusted covariables: age, sex, community urbanization, arrest location, witnessed status, bystander cardiopulmonary resuscitation, initial EMS rhythm, prehospital defibrillation, EMS response time interval, scene time interval, and EMS intravenous access.

DISCUSSION

In this study, outcomes according to TTI were compared in OHCA patients who did not achieve prehospital ROSC, and as the TTI increased, the neurologic and survival outcomes at discharge tended to be unfavorable. As the association between TTI and the out-

comes of OHCA patients without prehospital ROSC was analyzed using multivariable logistic regression adjusted for possible confounders, the aOR was found to be low in the patient group with a longer TTI. However, the effect of prolonged TTI on patient outcomes was insignificant when advanced airway management was performed.

Previous studies on TTI in OHCA have shown that TTI did not have a significant effect on patient outcome.[8,9,11] Therefore, there is evidence that with prolonged TTI it is more advantageous to transfer patients to a cardiovascular center of a higher level where appropriate treatment is possible, even for a long distance.[12,17] In most countries where previous studies were conducted, the EMS provider could perform ACLS for OHCA patients on scene.[8,9,11,13] However, in some countries, EMS providers are allowed to perform only limited interventions in the prehospital stage, which can lead to prolonged transport of OHCA patients without achieving ROSC.[6,7] There has been a lack of studies on the outcomes of patients who undergo long-distance transport without prehospital ROSC.[10]

When a patient is transferred before achieving prehospital ROSC, then high-quality CPR performed within the ambulance may be interrupted during the transport compared to the CPR executed on scene.[15,16,18] The effect of interrupted high-quality CPR ambulance on patient survival outcome is uncertain; however, the possibility of a deteriorating outcome is considered.[15,18,19]

Our result suggests that when EMS performed ETI before departure and decided to transfer the patient, the effect of TTI on outcomes might not be significant despite ROSC not being achieved. Our hypothesis is that chest compression can be sufficient only within a short period of arrest, but if it takes a longer time to transport the patient to an available ED, then the implementation of high-quality oxygen delivery procedure such as ETI would aid in oxygenation and ventilation in long-distance transport.[20-24]

Advanced airways are allowed only to a more educated and skilled EMT (level 1 EMT in Korea).[6,7] It is possible that, in OHCA, initial resuscitative management by the EMT, who can provide professional treatment, contributed to a favorable patient outcome. Therefore, performing advanced airway management before patient transport can indicate that sufficient prehospital treatment has been performed, and if adequate treatment is performed on-scene, then the outcome according to TTI may not be significantly different for patients who did not achieve ROSC. However, performing advanced medical procedures by the EMS provider is more difficult and sometimes delays the time to hospital arrival. The negative influence of delayed hospital transport time due to advanced airway management on-scene should also be considered.

In addition to cardiac arrest, patients with serious diseases such as critical trauma or stroke are transferred to a distant specialized center for regionalization, although the transport time is slightly longer.[25-27] In case of cardiac arrest without ROSC, it is necessary to carefully consider establishing a regional strategy for appropriate on-scene treatment and transport of the patient to a proper facility.

This study has several limitations. First, as this was a retrospective observational study and involved a multivariate analysis, it has limitations in adjusting for possible confounders compared to an intervention trial or a randomized controlled study. There are various factors affecting the outcome of OHCA. Because of the observational nature of the study and the presence of unmeasured potential confounding factors in this study, we could not conclude that a certain method or protocol is the best or the most optimal based on our study. Second, there is a possibility that TTI is not a result of the decision of EMS but a result of regional characteristics and cardiac arrest location. The proportion of metropolitan areas decreased as the TTI was longer in the study. Possible intervention variables were adjusted for; yet it is considered that other regional characteristics may have influenced the study results. Although the level of urbanization was included in the adjusted model, it might be debatable that urbanization is an appropriate variable for inclusion in adjustment because the level of urbanization might have already been included in the characteristics of EMS time variables such as TTI. Third, a longer TTI does not mean that the patients were transported to the higher level of ED. The current EMS protocol in Korea recommends transporting an OHCA patient without ROSC to the nearest ED available with prenotification to the hospital. Various factors may influence the selection of destination ED in cases of OHCA, such as the availability of ED, traffic status, and EMS resources.

In summary, hospital TTI was negatively associated with the neurologic outcome of OHCA without ROSC on scene. However, when ETI was performed on scene, TTI was insignificantly associated with the outcome. Performing advanced airway on scene may be considered when a longer hospital TTI is expected.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Original Article

Association of inferior vena cava diameter ratio with outcomes in patients with gastrointestinal bleeding

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Objective To examine the association of inferior vena cava (IVC) diameter ratio measured using computed tomography with outcomes in patients with gastrointestinal bleeding (GIB).

Methods A single-center retrospective observational study was conducted on consecutive patients with GIB who presented to the emergency department. The IVC diameter ratio was calculated by dividing the maximum transverse and anteroposterior diameters perpendicular to it. The association of the IVC diameter ratio with outcomes was examined using multivariable logistic regression analysis. The primary outcome was in-hospital mortality. The area under the receiver operator characteristic curve (AUC) of the IVC diameter ratio was calculated, and the sensitivity and specificity, including the cutoff values, were computed.

Results In total, 585 patients were included in the final analysis. The in-hospital mortality rate was 4.6% (n = 27). The IVC diameter ratio was significantly associated with higher in-hospital mortality in multivariable logistic regression analysis (odds ratio, 1.793; 95% confidence interval [CI], 1.239–2.597; P = 0.002). The AUC of the IVC diameter ratio for in-hospital mortality was 0.616 (95% CI, 0.498–0.735). With a cutoff of the IVC diameter ratio (≥ 2.1), the sensitivity and specificity for predicting in-hospital mortality were 44% (95% CI, 26%–65%) and 71% (95% CI, 67%–75%), respectively.

Conclusion The IVC diameter ratio was independently associated with in-hospital mortality in patients with GIB. However, the AUC of the IVC diameter ratio for in-hospital mortality was low.

Keywords Inferior vena cava; Gastrointestinal hemorrhage; Prognosis

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Capsule Summary

What is already known

The diameter of the inferior vena cava is associated with outcomes in trauma and other critically ill patients.

What is new in the current study

The inferior vena cava diameter ratio measured by computed tomography was independently associated with a poor outcome in patients with gastrointestinal bleeding.

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INTRODUCTION

Acute gastrointestinal bleeding (GIB) is a common presentation in the emergency department (ED), with a prevalence of approximately 45 to 172 per 100,000 individuals per year.[1,2] Data from the UK continue to show a mortality rate of 7% to 14%, imposing a significant burden on the healthcare system.[3-5] The technical developments in endoscopic hemostasis and the continued use of proton pump inhibitors are thought to have influenced the epidemiology and outcomes of peptic ulcer bleeding. Nevertheless, more than 60 of 100,000 patients are hospitalized for GIB in the US per year, with a remarkable mortality rate of 8% to 10%, and the cost associated with hospitalization is more than 100,000 US dollars per year.[1,6,7]

The severity of GIB varies from mild symptoms to death. Therefore, risk assessment is recommended in patients with GIB to predict outcomes, such as death and re-bleeding, and the need for clinical interventions, such as endoscopic hemostasis, transfusion, or radiologic intervention. Risk assessment is also necessary to determine the treatment level (inpatient vs. outpatient or general ward vs. intensive care unit).[8] There are many scores for risk stratification in patients with GIB. Among the various risk assessment scores, the Glasgow Blatchford score (GBS) and AIMS65 score (albumin <30 g/L [A], International normalized ratio >1.5 [I], altered mental state [M], systolic blood pressure ≤ 90 [S], and age >65 years [65]), which can be calculated without the need for endoscopy, are widely used.[9,10] However, the use of these scores for clinical decision-making is limited in the ED. Since GBS includes the presence of an underlying disease, it is problematic since definitions are subjective. The AIMS65 score effectively predicts mortality, but its predictive validity for other outcomes, such as the need for endoscopic hemostasis or blood transfusion, has not been established.[11-14] According to previous studies, inferior vena cava (IVC) collapsibility and diameter are known factors that can predict volume status.[15] In trauma or sepsis patients, the association between IVC diameter measured on computed tomography (CT) and patient prognosis has been reported.[16,17]

However, no study has addressed the predictive value of IVC diameter ratio in patients with GIB. CT is often performed in patients who visit the ED due to GIB. In a recent study, CT was recommended as a suitable modality to identify the source of acute GIB.[18-20] It can also be used to rapidly diagnose active bleeding. Therefore, considering these findings, the present study aimed to determine whether the IVC diameter measured on CT can help evaluate the prognosis of patients.

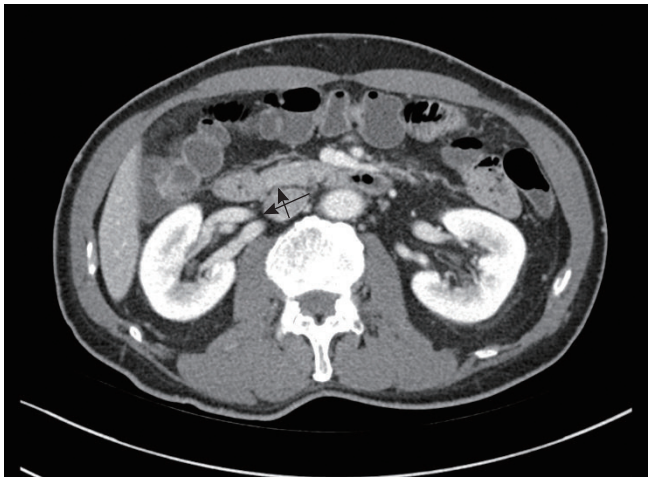

Fig. 1. Measurement of the maximal transverse diameter and the maximal anteroposterior diameter of the inferior vena cava (arrows).

METHODS

Ethical statements

This study was approved by the institutional review board of Hanyang University Hospital (No. HYUH 2020-11-010-004), and the need to obtain informed consent was waived due to the nature of the observational study. This study protocol was conducted in accordance with the Declaration of Helsinki and good clinical practice guidelines.

Study design and population

This was a retrospective observational cohort study of patients with GIB conducted between January 2016 and June 2020. The study included adults aged >18 years who visited the ED of a university-affiliated hospital in Seoul, Korea. We extracted the data of patients with GIB through a chart review. GIB was diagnosed when a patient visited the ED with one of the following chief complaints: hematemesis, melena, and hematochezia. The exclusion criteria were as follows: direct transfer to other hospitals from the ED, no CT examination, and patients who had signed a "do not attempt resuscitation order."

Definitions and outcomes

CT was performed by the treating physician on patients with GIB. Contrast-enhanced or non-contrast-enhanced CT was performed with an interval of 3 mm. The IVC diameter was measured using CT scans at a level just below the renal vein, which is the area least affected by patient breathing (Fig. 1).[21]

After assessing the maximum transverse diameter of the IVC, the anteroposterior diameter perpendicular to the transverse diameter was measured by an emergency medicine chief resident

who was blinded to patient outcomes. IVC diameter ratio was calculated as the maximal transverse diameter divided by anteroposterior diameter. The primary outcome of this study was in-hospital mortality. Secondary outcomes included endoscopic hemostasis, red blood cell transfusion, and radiologic embolization. Composite outcomes included in-hospital mortality and all secondary outcomes.

Statistical analysis

The study data were reported as mean±standard deviation or median with an interquartile range for continuous variables, as appropriate. Student t-test or Mann-Whitney U-test was used to compare continuous variables. The chi-square test or Fisher exact test was used to compare categorical variables. Logistic regression analysis was performed to assess the independent effect of IVC diameter ratio on in-hospital mortality, after adjusting for predefined confounding variables such as age, gender, GBS, AIMS65 score, systolic blood pressure (SBP), heart rate, heart failure, hypertension, diabetes mellitus, and liver cirrhosis. The area under the curve (AUC) was computed to examine the prognostic value of the IVC diameter ratio in predicting in-hospital mortality. Optimal threshold values were determined by maximizing the Youden index.[22] The sensitivity, specificity, positive predictive value, and negative predictive value of the IVC diameter ratio were calculated. A two-sided P-value of 0.05 was considered significant. All statistical analyses were performed using PASW Statistics ver. 18 (SPSS Inc., Chicago, IL, USA).

RESULTS

Participant characteristics

In total, 1,102 patients were screened by chart review from January 2016 to June 2020. Among these, 473 patients who did not undergo CT (Fig. 2), 14 patients who were transferred from the ED to another hospital, and 30 patients with "do not attempt resuscitation order" were excluded. Finally, 585 patients were in-

Table 1. Baseline characteristics of patients with gastrointestinal bleeding

Characteristic	Value
Age (yr), mean (SD)	62.5 (16.1)
Male sex	380 (65.0)
Initial vital signs, mean (SD)	
Systolic blood pressure (mmHg)	123 (27.0)
Diastolic blood pressure (mmHg)	69 (18.0)
Heart rate (beats/min)	94 (20.0)
Comorbidities	
Hypertension	153 (26.2)
Diabetes mellitus	93 (15.9)
Heart failure	11 (1.9)
Liver cirrhosis	126 (21.5)
Laboratory findings	
Hemoglobin (g/dL)	10.2 (7.9–12.5)
Platelet count (k/mm^3)	200 (126–365)
Creatinine (mg/dL)	0.8 (0.7–10.1)
BUN (mg/dL)	24.1 (16.1–37.0)
HCO_3 (mmol/L)	23.7 (20.8–25.7)
Treatment	
Endoscopic treatment	106 (18.1)
Transfusion	453 (77.4)
Outcome	
In-hospital mortality	27 (4.6)
Composite	471 (80.5)
Intervention	464 (79.3)
ICU admission	116 (19.8)
Other scores	
Glasgow Blatchford score	8 (5–12)
AIMS65 score	1 (0–2)

Values are presented as number (%) or median (interquartile range), unless otherwise indicated.
SD, standard deviation; BUN, blood urea nitrogen; ICU, intensive care unit; AIMS65, albumin <30 g/L (A), international normalized ratio >1.5 (I), altered mental state (M), systolic blood pressure ≤90 (S), and age >65 years (65).

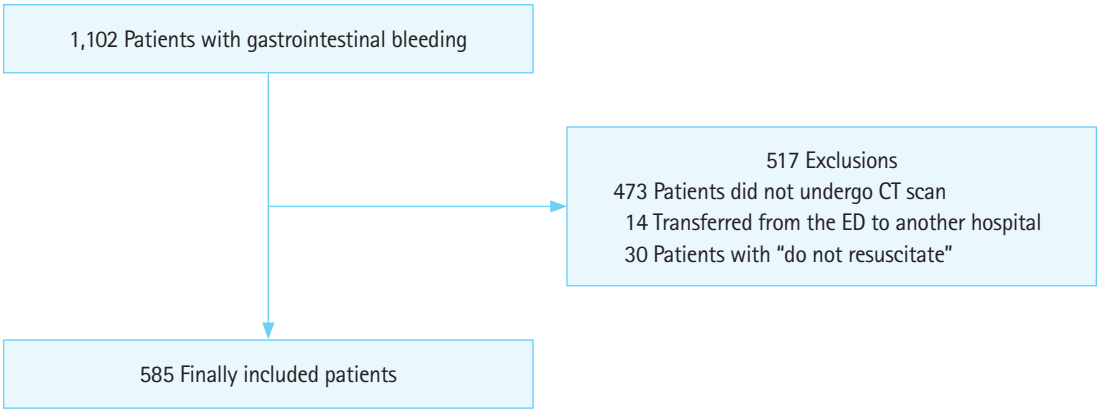

Fig. 2. Flow diagram showing the selection of the study population. CT, computed tomography; ED, emergency department.

Table 2. Multivariable logistic regression analysis of factors predicting in-hospital mortality

	Adjusted odds ratio (95% CI)	P-value
Age	1.032 (1.001–1.062)	0.040
Systolic blood pressure	0.977 (0.961–0.994)	0.007
Heart rate	1.021 (1.002–1.040)	0.032
Heart failure	13.988 (3.199–61.166)	<0.001
IVC diameter ratio	1.793 (1.239–2.597)	0.002

The model was adjusted for age, sex, Glasgow Blatchford score, AIMS65 score, systolic blood pressure, heart rate, heart failure, hypertension, diabetes mellitus, and liver cirrhosis.
CI, confidence interval; IVC, inferior vena cava; AIMS65, albumin <30 g/L (A), international normalized ratio >1.5 (I), altered mental state (M), systolic blood pressure ≤90 (S), and age >65 years (65).

cluded in the analysis. The mean age of the patients was 62.5 years, and 65.0% of the patients were male. The in-hospital mortality rate was 4.6% (n=27). Further, 80.5% of the patients showed a composite outcome (n=471). The median GBS and AIMS65 score were 8 and 1, respectively (Table 1).

Multivariable logistic regression analysis of factors predicting in-hospital mortality

Univariate logistic regression analysis of factors predicting in-hospital mortality was conducted in Supplementary Table 1. Multivariate logistic regression analysis was performed to examine the association between IVC diameter ratio and in-hospital mortality in patients with GIB (Table 2). The adjusted odds ratio (aOR) of the IVC diameter ratio for in-hospital mortality was 1.793 (95 % confidence interval [CI], 1.239–2.597), and it was statistically significant (P=0.002). Age, systolic blood pressure, heart rate, and heart failure were independently associated with in-hospital mortality (aOR, 1.032, 0.977, 1.021, and 13.988, respectively).

The AUC of the IVC diameter ratio for predicting in-hospital mortality was 0.616 (95% CI, 0.498–0.735) (Fig. 3). In addition, the AUCs of the IVC diameter ratio for predicting composite outcomes such as endoscopic hemostasis, red blood cell transfusion, radiologic embolization, and intensive care unit admission were 0.520 (95% CI, 0.458–0.582), 0.531 (95% CI, 0.476–0.587), 0.518 (95% CI, 0.379–0.656), and 0.534 (95% CI, 0.472–0.597), respectively (Supplementary Figs. 1-5). The cutoff value of the IVC diameter ratio for predicting in-hospital mortality, maximizing the sum of sensitivity and specificity, was 2.1. The overall diagnostic accuracy of the cutoff value of the IVC diameter ratio (≥2.1) was 70% (95% CI, 65%-74%). The sensitivity, specificity, positive predictive value, and negative predictive value of the cutoff values were 44% (95% CI, 26%–65%), 71% (95% CI, 67%–75%), 8% (95% CI, 5%–12%), and 96% (95% CI, 94%–97%), respectively.

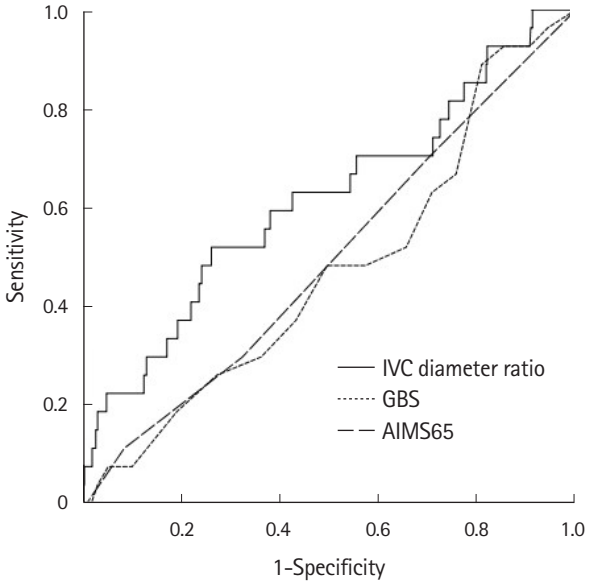

Fig. 3. Comparison of the inferior vena cava (IVC) diameter ratio with the Glasgow Blatchford score (GBS) and AIMS65 score for predicting in-hospital mortality. Area under the curve (AUC) of the IVC diameter ratio, 0.616 (95% CI, 0.498–0.735); AUC of the GBS, 0.472 (95% CI, 0.362–0.581); and AUC of the AIMS65 score, 0.496 (95% CI, 0.384–0.608). AIMS65, albumin <30 g/L (A), international normalized ratio >1.5 (I), altered mental state (M), systolic blood pressure ≤90 (S), and age >65 years (65).

DISCUSSION

The results of this study indicate that a high IVC diameter ratio measured by CT in patients with GIB was associated with poor outcomes. However, the AUC of the IVC diameter ratio was low (0.616), and the diagnostic accuracy of the optimal cutoff value was only 70%. Therefore, further studies should be conducted to validate the usefulness of IVC diameter ratio as a prognostic factor in patients with GIB.

To the best of our knowledge, the present study is the first to evaluate the association between the IVC diameter ratio measured on CT scans and in-hospital mortality in patients with GIB who visit the ED. Previous studies have investigated the association between IVC collapsibility or diameter, but not the IVC diameter ratio, and the outcomes of critically ill patients with various diseases. The strengths of this study include the inclusion of patients with GIB who underwent uniform treatment in a single institution. Unlike previous studies that used ultrasound, the diameter of IVC was measured more objectively using CT in the present study.

Numerous tools/scores have been used to evaluate the prognosis of patients with GIB. Although there are many scoring systems, the GBS and AIMS65 scores have been well validated in

many studies on GIB.[23,24] However, these scoring systems have limitations in identifying high-risk patients who may require inpatient endoscopy, embolization, or surgical treatment, as well as identifying patients at high risk of mortality, especially among those with GBS.[24-27] Moreover, the subjectivity of the definitions of hepatic disease and cardiac disease included in the GBS makes its application in clinical practice challenging.[28] A multicenter study revealed that a GBS of ≤ 1 appeared to be the optimum threshold for directing patients to outpatient management without endoscopy.[14] Although assessment using GBS can accurately identify low-risk patients suitable for early discharge, it cannot unequivocally identify individual patients who require intensive monitoring or are at risk of death.[29,30] In addition, GBS was inferior to the AIMS65 score in predicting inpatient mortality due to upper GIB, despite being superior in predicting blood transfusion.[24] The AIMS65 score was superior to the GBS in predicting mortality, but its predictive value for endoscopic hemostasis was inferior.[14] Furthermore, the use of AIMS65 score to identify patients at very low risk of re-bleeding or mortality is not recommended.[8] The AIMS65 score was designed to be used with high cutoff values to identify patients at high risk of mortality rather than to identify those at low risk with safe discharge.

Previous studies on patients with trauma or septic shock have reported that the IVC diameter predicts hypovolemia, blood loss, and in-hospital mortality.[31-33] They have also reported that the IVC diameter ratio was significantly correlated with markers of shock and was a predictor of mortality in patients with trauma and septic shock.[16,34] A retrospective cohort study reported that the IVC diameter ratio was significantly correlated with other known markers of shock and was an independent predictor of mortality in severely injured trauma patients.[16] In their study, the cutoff value for the IVC diameter ratio was defined as ≥ 1.9. They performed an AUC analysis to maximize the sensitivity and specificity of the IVC diameter ratio to predict mortality and arrived at a ratio of 1.9. In our study, the cutoff value for the IVC diameter ratio, maximizing both sensitivity and specificity, was 2.1. This is not significantly different from the cutoff value of 1.9 noted in trauma patients, and blood loss appears to be the main mechanism that causes shock in patients with GIB and trauma.

Ultrasonography is useful for measuring IVC diameter or changes in IVC diameter caused by respiration. However, the use of ultrasound has some drawbacks: there is variability in the results depending on the operator's skill, and accurate measurement is difficult when the patient is obese or has air in the bowel. CT is useful for quickly determining the bleeding site or active bleeding site in patients with GIB.[13,15,16] By addressing the association of the IVC diameter ratio assessed using CT with patient outcomes, our study might help in the rapid prognostic evaluation of patients with GIB who visit the ED.

This study has several limitations. First, 473 patients were excluded because they did not undergo CT, and the results of this study have a selection bias, making it difficult to extrapolate these results to the entire GIB population. A prospective study is needed to analyze the results of the IVC diameter ratio measurements using CT in all patients with GIB. Second, it is difficult to rule out selection bias in a single-center retrospective study. Third, the amount of fluid supplied before CT was not adjusted. Fourth, it was not specified whether positive pressure mechanical ventilation was performed during CT, which could have affected the diameter of IVC. However, because only six patients underwent mechanical ventilation, it did not appear to have affected the main results. Fifth, the IVC diameter ratio did not show superiority in diagnostic performance over the GBS and AIMS65 scores. However, simple measurement of the IVC diameter ratio seems to be a strength in that there is no significant difference in predictive power when compared to the complex scoring system. Finally, IVC diameter was measured by a single investigator, and the measured value was not compared with that of another investigator. Therefore, the possibility of bias in IVC diameter measurements cannot be ruled out.

In conclusion, the IVC diameter ratio measured on CT scans was independently associated with in-hospital mortality in patients with GIB. However, the AUC of the IVC diameter ratio for in-hospital mortality was low. Further prospective studies are needed to determine the prognostic value of the IVC diameter ratio.

SUPPLEMENTARY MATERIAL

Supplementary Fig. 1. Comparison of the inferior vena cava (IVC) diameter ratio with the Glasgow Blatchford score (GBS) and AIMS65 score for predicting composite outcomes.

Supplementary Fig. 2. Comparison of the inferior vena cava (IVC) diameter ratio with the Glasgow Blatchford score (GBS) and AIMS-65 score for predicting endoscopic hemostasis.

Supplementary Fig. 3. Comparison of the inferior vena cava (IVC) diameter ratio with the Glasgow Blatchford score (GBS) and AIMS-65 score for predicting red blood cell transfusion.

Supplementary Fig. 4. Comparison of the inferior vena cava (IVC) diameter ratio with the Glasgow Blatchford score (GBS) and AIMS-65 score for predicting radiologic embolization.

Supplementary Fig. 5. Comparison of the inferior vena cava (IVC) diameter ratio with the Glasgow Blatchford score (GBS) and AIMS-65 score for predicting intensive care unit admission.

Supplementary Table 1. Univariate logistic regression analysis of factors predicting in-hospital mortality

Supplementary materials are available from: https://doi.org/10.15441/ceem.21.099.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Original Article

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Time on shift in the emergency department and decision to prescribe opioids to patients without chronic opioid use

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Objective To study the effect of time on shift on the opioid prescribing practices of emergency physicians among patients without chronic opioid use.

Methods We analyzed pain-related visits for five painful conditions from 2010 to 2017 at a single academic hospital in Boston. Visits were categorized according to national guidelines as conditions for which opioids are "sometimes indicated" (fracture and renal colic) or "usually not indicated" (headache, low back pain, and fibromyalgia). Using conditional logistic regression with fixed effects for clinicians, we estimated the probability of opioid prescribing for pain-related visits as a function of shift hour at discharge, time of day, and patient-level confounders (age, sex, and pain score).

Results Among 16,115 visits for which opioids were sometimes indicated, opioid prescribing increased over the course of a shift (28% in the first hour compared with 40% in the last hour; adjusted odds ratio, 1.06; 95% confidence interval, 1.02–1.10; adjusted P-trend <0.01). However, among visits for which opioids are usually not indicated, relative to the first hour, opioid prescriptions progressively fell (40% in the first hour compared with 23% in the last hour; adjusted odds ratio, 0.93; 95% confidence interval, 0.91–0.96; adjusted P-trend <0.01).

Conclusion As shift hour progressed, emergency physicians became more likely to prescribe opioids for conditions that are sometimes indicated, and less likely to prescribe opioids for nonindicated conditions. Our study suggests that clinical decision making in the emergency department can be substantially influenced by external factors such as clinician shift hour.

Keywords Decision making; Opioid analgesics; Operations research

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CEEM

Capsule Summary

What is already known

Primary care physicians have been shown to become more lenient with prescribing antibiotics, as well as opioids, over the course of a clinic session. These findings have been attributed to decision fatigue, which is the erosion of self-control after making a large number of decisions.

What is new in the current study

This study examined the effect of time on shift on the opioid prescribing practices of emergency physicians. As shift hour progressed, emergency physicians became more likely to prescribe opioids for conditions that are sometimes indicated, such as fractures and renal colic, and less likely to prescribe opioids for nonindicated conditions such as headache, low back pain, and fibromyalgia.

INTRODUCTION

The opioid epidemic has led to critical self-reflection of when and for whom, to prescribe opioids from the emergency department (ED). Although emergency physicians tend to prescribe small quantities of opioids,[1] several studies have shown these prescriptions can still lead to misuse.[2,3] In one analysis, 36% of patients who were discharged from the ED with an opioid prescription self-reported medication misuse at the 30-day follow-up.[3]

Primary care physicians have been shown to become more lenient with prescribing antibiotics over the course of a clinic session.[4] More recently, this trend has also been observed in primary care settings for opioid prescriptions.[5] These findings have been attributed to "decision fatigue," which is the erosion of self-control after making a large number of decisions. Decision fatigue is demonstrated in other fields as well, such as in the justice system, where judges are more likely to deny parole, generally considered the "easier" or "safer" option, later in their session.[6] We sought to evaluate whether prescribing practices for opioids change over the course of an ED shift.

METHODS

Study design and ethics statement

This was a retrospective observational study of de-identified timestamped data. The study was approved by the institutional review board of Beth Israel Deaconess Medical Center (No. 2017 P-000593). Witten informed consent was waived due to the retrospective nature of the study.

Study setting

This study was conducted in an urban academic ED (Boston, MA, USA) staffed by attending physicians and residents, with approximately 55,000 annual visits. No advanced practice providers were included. Attending physicians and residents worked synchronized shifts, 8 to 9 hours in length. Residents self-assigned to patients according to the electronic rack order once patients entered the department; all patients seen by a resident are staffed by that resident's supervising attending physician. The final hour of each shift was dedicated to wrap-up, and physicians were not expected to see new patients during that hour, with the expectation that, at the end of a shift, signed-out patients had a clear disposition. Timestamps were automatically recorded by the electronic medical record system, including the time of patient discharge.

Study protocol

We identified visits for five pain-related conditions from 2010 to 2017 among adults without chronic opioid use from our electronic medical records using International Classification of Diseases 9 and 10 billing codes. Chronic opioid use was defined as having an existing prescription for an opioid medication in a patient's medication list. Participants included in our study were categorized by visit diagnosis as having conditions for which opioids are "sometimes indicated" (fracture and renal colic) or "usually not indicated" (headache, low back pain, and fibromyalgia) according to national guidelines.[7]

Our primary outcome was a binary indicator of whether opioids were prescribed at the time of a patient's discharge from the ED. The quantity and duration of the prescriptions were not captured in our dataset. Pain scores with a 0 to 10 scale were compared among patients for whom opioids were prescribed and not prescribed using the Wilcoxon Mann-Whitney test.

Our main independent variable was the hour of the attending physician's shift at which a patient was discharged from the ED (e.g., time at which a prescription was signed). This variable, which we call "shift hour," was calculated as the time from the start of the attending physician's shift to the time at which a pa-

Table 1. Patient characteristics for all visits according to whether an opioid was prescribed

Characteristic	Overall sample (n = 16,115)	Opioids not prescribed (n = 10,512)	Opioids prescribed (n = 5,603)	P-value
Age (yr)	44 (29–57)	42 (28–57)	45 (32–57)	< 0.01
Sex				< 0.01
Male	6,754 (42)	4,091 (39)	2,654 (47)	
Female	9,376 (58)	6,423 (61)	2,953 (53)	
Pain score	8 (5–9)	7 (5–9)	8 (6–10)	< 0.01
Time of day				< 0.01
7 a.m.–3 p.m.	3,594 (22)	2,201 (21)	1,393 (25)	
3 p.m.–11 p.m.	7,886 (49)	5,152 (49)	2,734 (49)	
11 p.m.–7 a.m.	4,635 (29)	3,159 (30)	1,476 (26)	
Opioids indicated				< 0.01
Sometimes indicated	6,538 (41)	3,900 (37)	2,638 (47)	
Usually not indicated	9,577 (59)	6,612 (63)	2,965 (53)	

Values are presented as median (interquartile range) or number (%). Data include all visits, including those for which the patient was discharged in the first hour of a clinician's shift.

tient was discharged, and it was treated as a categorical variable.

Patient-level information including age, sex, and pain score were recorded on presentation to the ED by nursing triage staff. Patients reported their pain using a previously validated numerical rating scale,[8] in which 0 was described as "no pain" and 10 was described as "the worst pain imaginable." Approximately 5% of our data had missing values for pain score, and these data were excluded from our analysis. Descriptive statistics are presented in Table 1. Data are expressed as medians with interquartile ranges for continuous variables and as the numbers with percentages for categorical data. Continuous variables were analyzed using the Wilcoxon rank-sum test, while categorical variables were analyzed using Pearson chi-square test.

Using conditional logistic regression, we estimated the multivariable-adjusted probability of opioid prescribing for pain-related visits as a function of shift hour, time of day at discharge, patient-level confounders (age, sex, and pain score), and fixed effects for attending clinicians. Time of day at discharge was chosen as a potential confounder to account for temporal trends in departmental boarding and crowding, which could influence provider decision-making. Conditional logistic regression is a standard approach for analyzing panel data, and it is used when subjects are measured at multiple time points. In our data, subjects (e.g., clinicians) were measured at hourly time points over the course of a shift (e.g., shift hour 1, 2, 3). Using conditional logistic regression with fixed effects by clinician, our results can be interpreted as "within group" (i.e., clinician-specific) effects. As Glober et al.[9] described previously, individual provider patterns of opioid prescribing may vary widely, suggesting the importance of clinician-specific models. Regressions were run separately among patients with conditions for which opioids are sometimes indicated and among those for which opioids were generally not indicated.

Table 2. Percentage of patients prescribed opioids, by condition

Condition	Sample size (% of subsample)	Patients prescribed opioids (%)
Opioids sometimes indicated	6,538	40
Fracture	6,287 (96)	39
Renal colic	251 (4)	75
Opioids generally not indicated	9,577	31
Lower back pain	5,034 (52)	49
Headache	4,091 (43)	10
Fibromyalgia	452 (5)	14

In sensitivity analyses, we excluded discharges that took place in the first hour of a physician's shift, under the assumption that these would be primarily signed-out patients for whom the discharge plan had been formulated by the previous provider. This exclusion accounted for less than 1% of the overall sample and had no effect on our overall conclusions.

RESULTS

There were 16,115 pain-related visits that met our inclusion criteria; 35% resulted in a new opioid prescription. Demographics were similar for patients for whom opioids were prescribed and not prescribed (Table 1). Pain scores were higher for patients who received opioid prescriptions ($P < 0.01$).

Among patients included in our study who had conditions for which opioids are sometimes indicated, the vast majority had a fracture; patients with renal colic accounted for < 5% of total cases (Table 2). Patients in our study who had conditions for which opioids are generally not indicated primarily presented

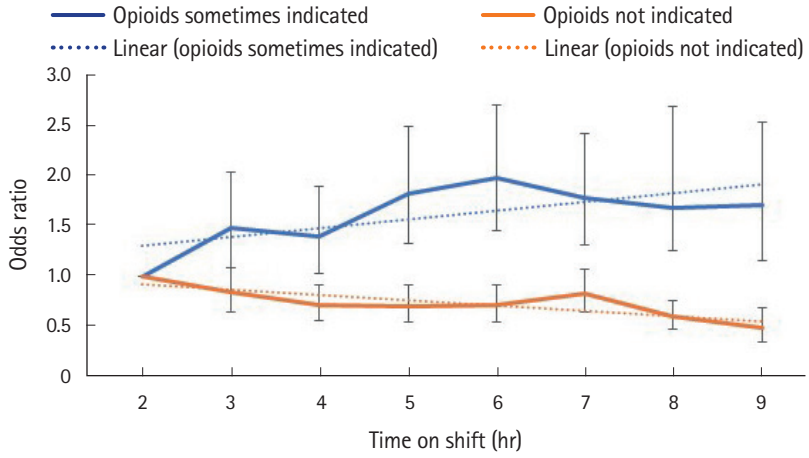

Fig. 1. Multivariable-adjusted odds ratio and 95% confidence interval for prescribing opioids over the course of a shift, by visit type.

Table 3. Actual percentage of patients prescribed opioids by shift hour of the prescribing physician

Variable	Shift hour							
	2	3	4	5	6	7	8	9
Opioids sometimes indicated (%)	28	37	38	43	44	43	42	40
Opioids not indicated (%)	40	35	33	32	30	33	27	23
Overall sample (%)	35	36	35	36	35	36	32	29

Confidence intervals not provided as data are actual raw percentages (not calculated).

with headache or lower back pain; 5% presented for fibromyalgia. The percentage of patients prescribed opioids was higher among conditions for which opioids are sometimes indicated.

Our multivariable-adjusted results are presented in Fig. 1. Among visits for which opioids are sometimes indicated, prescribing increased per hour on shift (adjusted odds ratio, 1.06; 95% confidence interval, 1.02–1.10; P-trend <0.01). However, among visits for which opioids are usually not indicated, opioid prescriptions fell per hour on shift (adjusted odds ratio, 0.93; 95% confidence interval, 0.91–0.96; P-trend <0.01). Unadjusted results are provided in Table 3.

DISCUSSION

We found that as shift hour progressed, emergency physicians became more likely to prescribe opioids for conditions that are sometimes indicated, such as fractures and renal colic, and less likely to prescribe opioids for nonindicated conditions such as headache, lower back pain, and fibromyalgia. Few studies have examined the effects of visit timing or shift hour on opioid prescribing practices,[5] and none have examined these trends among emergency physicians. In the primary-care literature, two recent studies found that primary care physicians were more likely to prescribe both antibiotics[4] and opioids[5] over the course of a clinic session and as appointments run later throughout the day in a linearly increasing pattern.

In our study, we similarly found that for conditions for which opioids are sometimes indicated, specifically fracture and renal colic, emergency physicians became more permissive with prescribing opioids over the course of a shift. We are unable to confirm the exact mechanisms driving these findings as we did not observe physicians' reasoning or thought processes in our data. However, our findings do support previously proposed hypotheses, including decision fatigue and the desire to move patients through the department more quickly in the face of increasing time pressure. Theoretically, decision fatigue is a term that refers to the cumulative cognitive demand of repeated decision making, which may erode a clinician's self-control.[10] According to the psychological literature, self-control may be a limited and consumable resource, which degrades over time with continuous self-control effort.[10] As prior studies have suggested, time is needed to explain nonopioid alternatives for pain management and to avoid opioid prescribing risks, making visits longer and requiring physicians to spend precious time dealing with disappointed patients.[5] In a qualitative study of cancer patients with chronic pain and their outpatient clinicians, Satterwhite et al.[11] described opioid prescribing as "time intensive and stress-inducing in the context of short visits." In the same study, one clinician stated, "I think maybe the over-prescribing [of opioids] is a reflection that we have no time with people."

Surprisingly, we also found that for conditions for which opioids are generally not indicated, such as headache, lower back pain, and fibromyalgia, emergency physicians appeared to become less permissive with opioid prescribing over the course of a

shift. Though unexpected, this was a robust result. We propose several possible explanations for this trend, though further research will be required to investigate these explanations given the limitations of our dataset. One possibility is that, unlike primary care physicians, emergency physicians are unlikely to encounter the same patient in the future, and they may face less pressure to provide prescriptions for nonindicated conditions for the sake of maintaining a patient relationship. Therefore, it may be less mentally taxing for an emergency physician to deny a patient a prescription for opioids compared with a primary care physician. Alternatively, because our data was collected in Massachusetts, where mandatory referencing of prescription drug monitoring programs creates additional effort to look up a patient through a dedicated web portal prior to providing an opioid prescription, emergency physicians may be less willing to prescribe opioids for nonindicated conditions when under mounting time pressure toward the end of a shift. In one prior study, Keister et al.[12] found that emergency physicians are less likely to prescribe opioids when the ED is crowded. Our results are internally consistent, in that time pressure appears to be correlated with a decreased likelihood of providing opioid prescriptions for some patient populations. Ultimately, further research is required to validate our findings in other datasets and study contexts and to investigate possible explanations for our findings.

Our research should be interpreted in the context of the study design, which is a retrospective observational study among patients without chronic opioid use. Each visit to the ED was treated individually. Identifiable data linking visits to specific patients was not included in our dataset. Furthermore, our data were drawn from a single academic tertiary hospital in an urban setting and may not be generalizable to community or county EDs. A limitation of our study is that the quantity and duration of opioid prescriptions was not captured in our dataset, and while this nuance is outside the scope of our current study, it would be an avenue for future research on this topic. We also did not capture pain duration prior to ED visit, effectiveness of prior pain therapies, pain score over the course of the ED visit (only on arrival), or detailed diagnoses such as complex ankle fracture versus small avulsion fracture, which could affect opioid prescribing. Approximately 5% of our patient sample had missing values for pain score, and these patients were excluded from our analysis. Another limitation of our study is the limited sample size for several of the included conditions (renal colic and fibromyalgia), which together made up only < 10% of the available data.

The hospital in which our study was conducted is staffed by both attending physicians and residents, and while patient care is ultimately the responsibility of the attending, residents are typically the providers who write the physical prescriptions at discharge. We calculated shift hour based on the attending physician's shift, which was usually, but not always, the same as the shift hour of the resident seeing the patient (though without any systematic error). Our data did not capture resident identifiers and therefore we were unable to perform analyses according to resident shift hour. However, it is unlikely that the prescriptions written by residents reflected all those and only those that would have been written by the attending. Therefore, the observed trends could be potentially even stronger in an attending-only or community setting.

Many efforts are ongoing to limit opioid prescriptions, including prescription monitoring databases[13] and clinician education curricula.[14] Our study suggests that clinical decision making can be meaningfully influenced by external factors such as clinician shift hour. Standardized decision-making algorithms and shared decision-making tools could help to mitigate the effects of external factors and promote optimal opioid prescribing practices regardless of shift hour. Ultimately, we encourage additional research to investigate the impact of shift timing on emergency physician prescribing practices.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Original Article

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Characteristics of frequent emergency department users in Korea: a 4-year retrospective analysis using Korea Health Panel Study data

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Objective We aimed to investigate the characteristics of frequent emergency department (ED) users in Korea.

Methods We analyzed the Korea Health Panel Study data of a sampled population from the 2005 Population Census of Korea data, and adults (age ≥18 years) who visited the ED at least once a year between 2014 and 2017 were included in the study. People who visited three or more times a year were classified as frequent users. We compared demographic, socioeconomic, and health-related factors between nonfrequent and frequent users. We used a multivariable logistic regression analysis to determine factors related to frequent ED visits. We also compared the characteristics of ED use in both nonfrequent and frequent users.

Results A total of 5,090 panels were included, comprising 6,853 visits. Frequent users were 333 (6.5% of all panels), and their ED visits were 1,364 (19.9% of all ED visits). In the multivariable regression analysis, medical aid coverage (adjusted odds ratio [aOR] of the National Health Service coverage, 0.55; 95% confidence interval [CI], 0.40–0.75), unemployment (aOR of employment, 0.72; 95% CI, 0.56–0.91), prior ward admission in a year (aOR, 2.14; 95% CI, 1.67–2.75), and frequent outpatient department use (aOR, 1.72; 95% CI, 1.35–2.20) were associated with frequent use. Moreover, frequent users visited the ED of public hospitals more often than than nonfrequent users (19.2% vs. 9.8%). Medical problems rather than injury/poisoning were the more common reasons for visiting the ED (84.5% vs. 71.2%).

Conclusion We found that frequent ED users were likely to be those with socioeconomic disadvantage or with high demand for medical service. Based on this study, further studies on interventions to reduce frequent ED use are required for better ED services.

Keywords Hospital emergency service; Emergencies; Epidemiology; Frequent user

Capsule Summary

What is already known

Frequent emergency department visits are one of the main sources of emergency department input, leading to emergency department overcrowding.

What is new in the current study

Older people, those with low levels of education, unemployment, low household income, medical aid coverage, prior ward admission, and frequent outpatient department use were more likely to be frequent users.

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INTRODUCTION

Emergency department (ED) overcrowding is a challenging issue because it is closely related to decreased quality of care, safety concerns, reduced patient satisfaction, and increasing medical costs.[1-3] The volume of ED attendance has increased in many developed countries, ranging from 3% to 6% annually.[4] Frequent ED users were defined as people who visit ED multiple times in a year in previous studies, and they may be a factor contributing to the increasing volume of ED attendance. Because the threshold of multiple ED use was different among the studies (range of 2 to 10 times in a year),[5] statistics about frequent ED users differed in previous studies. In Korea, 3.1% of ED visitors were denoted as frequent ED users (ED attendance more than four times a year), accounting for 14% of all ED visits in 2009.[6] A previous systematic review revealed that frequent ED users accounted for only 4.5% to 8% of all ED patients, but corresponded to 21% to 28% of all ED visits.[5]

Thus, it is important to investigate the characteristics of frequent ED users to serve as baseline data for future studies or to underpin policy for decreasing ED "input." Most previous studies on this issue were hospital-based; thus, they have limited generalizability. Moreover, there are only a few reports on this issue in Korea. Although a single population-based study evaluated the characteristics of frequent ED visits in Korea, the study utilized insurance claim data only, and the number of variables was insufficient to explain the association with frequent ED visits.[6] In our study, we investigated demographic, socioeconomic, and personal health-related factors and we evaluated the association of these factors with frequent ED visits using population-based data from a nationwide medical panel survey.

METHODS

Study design

This retrospective observational study was conducted after approval by the ethics committee of Inje University Ilsan Paik Hospital (No. 2021-08-010). We analyzed fully anonymized data of the Korea Health Panel Study (KHPS) version 1.6 for a 4-year period (2014–2017). Informed consent was waived because of the retrospective nature of the study.

The KHPS data has been collected by the Korea Institute for Health and Social Affairs and the National Health Insurance Service since 2008 and is an official statistical investigation. The KHPS gathered baseline data about medical service and expenditures, and insurance coverage for health care and health insurance policies. The sampling frame was 90% of the national population in the 2005 Population Census of Korea, and a two-stage probability proportionate, and stratified cluster sampling method was adopted. In the first step, the population was stratified in accordance with geographic area using household registries (16 metropolitan cities and provinces, and two towns), yielding 237,165 clusters. Next, a total of 350 sample clusters were extracted from the whole population cluster, and then sample households were extracted from the sample clusters. Finally, family members from the sample households were denoted as Korean health panels. At inception, approximately 8,000 households across the nation were sampled. The survey was conducted by trained investigators once a year based on self-reporting questionnaires and in-person interviews. Receipts for medical expenses and prescriptions were used as supporting evidence for the use of medical services.

Subjects

We included adults (age ≥18 years) who visited the ED at least once in a calendar year between 2014 and 2017. A panel in each year was considered an independent case if a panel met the inclusion criteria for multiple years. We operationally defined three or more visits in a year as the threshold of "frequent ED visits" used in the previous study.[7]

Data collection and statistical analysis

First, demographic data were collected for each patient including sex, age, marital status, education, national health insurance service type, employment, household income, region of residence, presence of disability, presence of chronic illness, medication use for chronic conditions, household income, frequency of annual ED visits and outpatient department (OPD) visits (visits within a calendar year), and prior hospital ward admission within a calendar year. Next, we gathered information about ED service: transport method to the ED, reason for the visit, day of visit (weekday or weekend), medical services provided, primary diagnosis, discharge after ED treatment, and the ownership and grade of hospital.

The variables were categorized as follows: patients were grouped into four age ranges (18–34, 35–49, 50–64, and ≥ 65 years), and the region of residence was divided into three groups (capital, metropolitan city, and province). Income was classified into quintiles (fifth quintile designated as the highest household income). The average number of OPD visits of included panels was 19, thus we defined panels who visited the OPD 19 or more times in a year as frequent OPD visitors. When a panel visited the ED three times or more in a year, they were categorized as frequent ED users. The transport method was categorized as public ambulance, private ambulance, or self. Hospitals were categorized into three groups (tertiary hospital, general hospital, and hospital/clinic); hospital

ownership was categorized as private or public. Case dispositions were classified as admission (admitted or transferred to another hospital) or discharged home.

The panels were divided into two groups according to the frequency of ED visits: nonfrequent ED visits and frequent ED visits. The frequency and percentage of the following panel's personal characteristics were calculated, and the differences between groups were evaluated using the chi-square test or Fisher exact test; sex, age group, marital status, education, household income, region of residence, insurance type, employment, disability, presence of chronic disease, prior ward admission within a calendar year, frequent OPD user and medication use for chronic conditions. Multiple logistic regression analysis was performed to determine factors associated with frequent ED visits (three or more in a year). Finally, we compared the following factors related to ED services between the two groups using the chi-square test or Fisher exact test; hospital ownership, hospital grade, transport method, reason for visit, day of visit, medical services provided, ED discharge, ED satisfaction, and primary diagnosis. For this analysis, each ED visit was considered an independent visit. We conducted statistical analysis using IBM SPSS ver. 21 (IBM Corp., Armonk, NY, USA), and a P-value <0.05 was considered to be statistically significant.

RESULTS

A total of 5,090 panels accounting for a total of 6,853 ED visits were noted in the study period. There were 333 frequent users (6.5% of all panels), accounting for 1,364 ED visits (19.9% of all ED visits).

The characteristics of nonfrequent and frequent ED users

The older age group (age ≥ 65 years) showed a higher proportion of frequent users (54.1% vs. 38.2%) (Table 1). Patients with a low level of education (under high school graduates), patients with a low household income (first and second quintiles) and those that were unemployed were more frequent users (79.3% vs. 70.3%, 50.1% vs. 41.4%, and 61.3% vs. 48.0%). Patients with medical aid coverage accounted for more frequent users (18.0% vs. 8.1%). A high proportion of frequent ED users was made up of patients with relatively high medical use (prior ward admission, frequent use of OPD, and the presence of chronic disease).

A regression analysis of patients' characteristics with frequent ED use

NHS coverage and employment showed a lower association with frequent ED use; odds ratio (95% confidence interval) of 0.55 (0.40-0.75) and 0.72 (0.56-0.91), respectively (Table 2). Converse-

Table 1. Demographics and socioeconomic characteristics of frequent and nonfrequent emergency department users

Characteristic	Nonfrequent user (n = 4,757)	Frequent user (n = 333)	P-value
Sex			0.16
Male	2,182 (45.9)	166 (49.8)	
Female	2,575 (54.1)	167 (50.2)	
Age (yr)			< 0.01
18–34	729 (15.3)	40 (12.0)	
35–49	932 (19.6)	46 (13.8)	
50–64	1,278 (26.9)	67 (20.1)	
≥ 65	1,818 (38.2)	180 (54.1)	
Marital status			0.10
Married	3,234 (68.0)	215 (64.6)	
Divorced/separated	835 (17.6)	74 (22.2)	
None	688 (14.4)	44 (13.2)	
Education			< 0.01
University	1,412 (29.7)	69 (20.7)	
High school	1,409 (29.6)	88 (26.4)	
Middle school	642 (13.5)	55 (16.5)	
Elementary	999 (21.0)	90 (27.0)	
None	295 (6.2)	31 (9.3)	
Coverage			< 0.01
National Health Service	4,374 (91.9)	273 (82.0)	
Medical aid	383 (8.1)	60 (18.0)	
Employment			< 0.01
Yes	2,476 (52.0)	129 (38.7)	
No	2,281 (48.0)	204 (61.3)	
Disability			0.02
Yes	521 (11.0)	51 (15.3)	
No	4,236 (89.0)	282 (84.7)	
Chronic disease			< 0.01
Yes	3,633 (76.4)	291 (87.4)	
No	1,124 (23.6)	42 (12.6)	
Income			< 0.01
Quintile 1	984 (20.7)	95 (28.5)	
Quintile 2	986 (20.7)	72 (21.6)	
Quintile 3	952 (20.0)	66 (19.8)	
Quintile 4	956 (20.1)	55 (16.5)	
Quintile 5	879 (18.5)	45 (13.5)	
Residence			0.24
Capital	476 (10.0)	31 (9.3)	
Metropolitan	1,340 (28.2)	81 (24.3)	
Others	2,941 (61.8)	221 (66.4)	
Ward admission			< 0.01
Yes	2,272 (47.8)	234 (70.3)	
No	2,485 (52.2)	99 (29.7)	
OPD ≥ 19 times per year			< 0.01
Yes	2,276 (47.8)	220 (66.1)	
No	2,481 (52.2)	113 (33.9)	
Medication			0.53
Yes	559 (11.8)	43 (12.9)	
No	4,198 (88.2)	290 (87.1)	

Values are presented as number (%).
OPD, outpatient department.

Table 2. Logistic regression analysis including demographic and socioeconomic factors associated with frequent emergency department visits

Variable	Unadjusted OR	95% CI	Adjusted OR	95% CI
Sex				
Male	Reference		Reference	
Female	0.85	0.68–1.07	0.79	0.63–1.00
Coverage				
Medical aid	Reference		Reference	
NHS	0.40	0.30–0.54	0.55	0.40–0.75
Employment				
No	Reference		Reference	
Yes	0.58	0.46–0.73	0.72	0.56–0.91
Ward admission within a year				
No	Reference		Reference	
Yes	2.59	2.03–3.29	2.14	1.67–2.75
No. of OPD visits (per year)				
< 19	Reference		Reference	
≥ 19	2.12	1.68–2.68	1.72	1.35–2.20

OR, odds ratio; CI, confidence interval; NHS, National Health Service; OPD, outpatient department.

ly, ward admission and frequent use of the OPD were greatly associated with frequent ED use; odds ratio (95% confidence interval) of 2.14 (1.67-2.75) and 1.72 (1.35-2.20), respectively.

The characteristics of ED services of nonfrequent users and frequent users

Frequent users visited public hospital EDs more often than private hospital EDs (19.2% vs. 9.8%) (Table 3). The proportion of ED visitors with medical problems was higher in the frequent user group than in the nonfrequent user group (84.5% vs. 71.2%). The proportion of surgical treatment was higher in the nonfrequent user group (4.4% vs. 1.5%). Among medical diagnoses, the proportion of cardiologic, pulmonary, and hematologic/oncologic diagnoses was higher in the frequent user group (10.9% vs. 7.4%, 13.9% vs. 11.3%, and 10.5% vs. 3.0%).

Table 3. Characteristics of emergency department use in nonfrequent and frequent emergency department users

Characteristic	Nonfrequent user (n = 5,489)	Frequent user (n = 1,364)	P-value
Hospital ownership			
Public	539 (9.8)	262 (19.2)	< 0.01
Private	4,950 (90.2)	1,102 (80.8)	
Hospital grade			
General hospital	4,075 (74.2)	973 (71.3)	0.09
Hospital	1,369 (24.9)	380 (27.9)	
Clinics	45 (0.8)	11 (0.8)	
Transport			
Public ambulance	1,198 (21.8)	262 (19.2)	< 0.01
Private ambulance	102 (1.9)	53 (3.9)	
Self	4,189 (76.3)	1,049 (76.9)	
Reason for visit			
Medical	3,909 (71.2)	1,153 (84.5)	< 0.01
Injury/poisoning	1,580 (28.8)	211 (15.5)	
Day of visit			
Weekday	3,449 (62.8)	890 (65.2)	0.10
Weekend	5,489 (37.2)	1,364 (34.8)	
ED treatment			
Surgery	241 (4.4)	21 (1.5)	< 0.01
Medication/treatment	5,064 (92.3)	1,316 (96.5)	
Examination	184 (3.4)	27 (2.0)	
ED discharge			
Home	3,745 (68.2)	966 (70.8)	0.06
Admission	1,744 (31.8)	398 (29.2)	
ED satisfaction			
Yes	4,609 (84.0)	1,131 (82.9)	0.35
No	880 (16.0)	233 (17.1)	
Diagnostic category			
Gastroenterology	612 (11.1)	128 (9.4)	< 0.01
Pulmonology	622 (11.3)	190 (13.9)	
Cardiology	406 (7.4)	149 (10.9)	
Injury/poisoning	1,537 (28.0)	206 (15.1)	
Infectious disease	329 (6.0)	50 (3.7)	
Urology/gynecology	208 (3.8)	40 (2.9)	
Hematology/oncology	164 (3.0)	143 (10.5)	
Others	1,611 (29.3)	458 (33.6)	

Values are presented as number (%).
ED, emergency department.

DISCUSSION

The primary role of the ED is to provide qualified and timely medical treatment for those with urgent and emergent medical conditions. However, many studies have reported that a significant proportion of ED patients visit the ED with nonurgent problems.[8,9] In a systematic review by Uscher-Pines et al.[9] the range of nonurgent visits was 8% to 62% of all ED visits. Reasons for nonurgent visits include a lack of primary care, easy accessibility, or time constraints due to work. In a previous report, frequent ED visits were associated with a higher probability of having a nonurgent problem.[10] Considering that frequent ED visits are one of the main sources of ED input and is closely related to nonurgent visits, our study may be significant in terms of providing background data.

In this study, females comprised a relatively lower proportion of frequent ED users and had a lower probability of frequent ED visits, despite a lack of statistical significance. Likewise, in a previous cross-sectional study in Korea, females showed a lower likelihood of frequent ED visits compared to males.[6] Results of sex prevalence were heterogeneous in a previous systematic review

in the US.[11] Therefore, further studies are required to determine the effect of sex on frequent ED visits in Korea.

Older patients (≥ 65 years) comprised a higher proportion of frequent ED users, but age was not found to be a contributing factor for frequent ED visits in this study. Conversely, in a previous systematic review of the US, patients in younger age groups were more likely to be frequent ED visitors than older age groups (≥ 65 years).[11] This may be explained by differences in the medical environment, such as the degree of accessibility to primary care centers or EDs.

In Korea, almost all people are beneficiaries of either national health services or medical aid. Medical aid beneficiaries are low-income individuals with a low burden on their medical costs for most medical services. In our study, those with medical aid coverage comprised a higher proportion of frequent visitors and showed relatively higher odds of frequent ED visits. We can infer that these patients have a relatively higher requirement for emergency care with the advantages of an ED, such as greater accessibility and expedited specialist consultation, even with a low burden on medical costs. Similarly in a previous report, members of the public or those with medical aid coverage were more likely to be frequent ED users.[12,13]

Sun et al.[14] reported that social disadvantages such as a low level of education and unemployment were factors associated with frequent ED visits. In our study, a low level of education was prevalent in a relatively high proportion of frequent ED users, which is similar to two previous reports.[13,15] Unemployed patients were more likely to be frequent ED users and showed greater probability of frequent ED visits in our study. This result is similar to previous reports based in the US in which unemployed patients accounted for about 85% of frequent users (vs. 40% of nonfrequent users; odds ratio, 1.4).[16,17]

Patients with disabilities or chronic disease comprised a higher proportion of frequent ED users in our study. In keeping with the KHPS definitions, we operationally defined patients with either of the following conditions as having chronic disease: hypertensive disease (I10-I15 in International Classification of Diseases 10th revision, clinical modification code), diabetes mellitus-related conditions (E10-E14), disorder of lipoprotein metabolism and other lipidaemia (E78), arthropathy (M00-M25), tuberculosis (A15-A19), ischemic heart disease (I20-I25), and cerebrovascular disease (I60-I69). The link between chronic conditions/comorbidities and frequent ED visits was also found in other reports.[15,18,19]

Ward admission and frequent OPD visits were found to be contributing factors associated with frequent ED visits in this study. This finding is in accordance with those of previous studies in Taiwan and Sweden.[3,20] In a study by Huang et al.[3] persistent use of the hospital OPD and the prior hospital admission was four and three times more prevalent in frequent ED users (three times per year) than single ED users. Hansagi et al.[20] reported that frequent ED users were 3.4 times more likely to use primary care facilities than nonfrequent ED users. This implies that those who have higher needs (real or patient-perceived) for healthcare tend to visit the ED more.

This study has some limitations. First, because the panel survey was conducted retrospectively, there is a potential for recall bias. However, most of the data were collected based on objective evidence, such as receipts of medical payments and medical records to minimize recall bias. Second, a few factors known to be related to frequent ED visits, such as comorbidities (heart disease or psychiatric disorders) and presence of usual sources of primary care, were not considered.

In conclusion, medical aid coverage, unemployment, ward admission in a calendar year, and frequent OPD use were associated with factors for frequent ED visits. Frequent users visited the ED of public hospitals more, and medical problems were more common reasons for visits rather than injury/poisoning. The result of our study might serve as a baseline data for future studies or policies on interventions to reduce frequent ED visits.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Original Article

Suicide attempts presenting to the emergency department before and during the COVID-19 pandemic: a comparative study

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Objective To compare and analyze the differences in the sociodemographic and clinical characteristics of suicide attempters who visited an emergency department (ED) before and during the coronavirus disease (COVID-19) pandemic.

Methods This single center, retrospective study was conducted by reviewing the medical records of patients in the "self-injury/suicide" category of the National Emergency Department Information System who visited an ED between January 2019 and December 2020. We obtained information on baseline characteristics, suicide attempt, and disposition. Data were analyzed using the chi-squared test.

Results A total of 456 patients were included. The number of patients visiting the ED for suicide attempts increased by 18.2% (from 209 to 247 cases) during the COVID-19 pandemic, and the ratio of suicide attempters to the total number of ED visits increased by 48.8% (from 0.43% to 0.64%, $P < 0.001$). There were significant differences in methods of suicide attempt, endotracheal intubation, ED disposition, and the presence of mental illness. Drug overdose (42.1% vs. 53.4%) and gas inhalation (5.7% vs. 8.5%) increased, and hanging decreased (6.0% vs. 2.0%) during the pandemic. Endotracheal intubation (13.9% vs. 5.7%) and intensive care unit admission (29.7% vs. 14.6%) decreased. More patients with the history of mental illness visited during the pandemic (54.0% vs. 70.1%).

Conclusion Since the COVID-19 pandemic began, suicide attempts have increased in this single ED although the lethality of those attempts is low.

Keywords COVID-19; Suicide attempt; Mental health

Capsule Summary

What is already known

The COVID-19 pandemic is adversely affecting public mental health.

What is new in the current study

During the COVID-19 pandemic, suicide attempts have increased in this single center study. Although the lethality of those attempts has been low, the study findings suggest that interventions including preventive measures for suicide attempts, screening of high-risk patients, and a postmanagement process for patients with mental health problems are needed.

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INTRODUCTION

Suicide is a global social problem, particularly in Korea. The suicide rate in Korea was 24.6 per 100,000 people in 2019, which is more than double the Organization for Economic Cooperation and Development average suicide rate of 11.0.[1] Suicide attempts are acts committed with an intent to die that do not cause death but potentially injure the attempter.[2] They are the steps that lead to suicide, and the results range from mild to critical injury, depending on the method and severity of the attempt. In addition to evaluations of the physical injuries, mental health evaluations are required in emergency departments (EDs) whenever patients show an intention toward or evidence of self-injury.

Coronavirus disease 2019 (COVID-19), reported for the first time at the end of 2019, is an infectious disease that has caused a global pandemic, with no effective treatment yet available. A similar global infectious disease before the COVID-19 pandemic was the Spanish flu, which passed through two waves from 1918 to 1920, infecting about a third of the world's population and killing 50 million people.[3,4] One study reported that fear of infection, isolation, disconnection, and quarantine were associated with increased suicide rates during the Spanish flu outbreak.[3]

Before COVID-19, the most recent infectious disease outbreak in Korea was Middle East respiratory syndrome. The first confirmed case was reported in Korea on May 20, 2015, and since then, 186 people were infected, and 38 people died.[5] Of the 1,656 people who were kept in quarantine and received a final negative test, 7.6% complained of anxiety.[6] In a study of those who were infected with Middle East respiratory syndrome and survived, 42.9% had posttraumatic stress disorder, and 27.0% had depressive disorder.[7] Similarly, in a study of 402 survivors of COVID-19 infection, 42% had anxiety, 31% had depression, and 28% had posttraumatic stress disorder.[8]

Reports detailing how the COVID-19 pandemic has affected the mental health of the general population are increasing. A study of 1,201 individuals from the general population in China found that 16.5% had moderate depression and 28.8% had moderate to severe anxiety about the COVID-19 pandemic.[9] A larger study of 52,730 people from, China, Hong Kong, Macau, and Taiwan reported a mental distress rate of 35%.[10]

In summary, the COVID-19 pandemic is adversely affecting the mental health of the general population, as well as people made vulnerable by preexisting mental illness. Previous studies have dealt with the effects of COVID-19 on mental health, but few have examined suicide attempts associated with the pandemic.

In this study, we investigate the sociodemographic and clinical characteristics of suicide attempters who visited an ED before and during the COVID-19 pandemic.

METHODS

Study design and participants

This study evaluated patients who visited a regional emergency medical center in Gyeonggi Province, Korea. This is a retrospective observational study using the medical records of patients who visited the ED between January 1, 2019 and December 31, 2020. According to the categories of the National Emergency Department Information System, patients that met the criteria for "self-harm/suicide" and were included in our analyses. We excluded patients whose records indicated that they did not attempt suicide and patients from outside the region who were admitted with carbon monoxide poisoning. This retrospective study was exempted from approval by the institutional review board of Myongji Medical Foundation (No. MJH 2021-04-017).

Data

We obtained information about patients' age, sex, method of suicide attempt, suicide attempt history, presence of mental illness, cause of suicide attempt, occupation, family history, endotracheal intubation, and disposition from the medical records.

Analysis

Counts and percentages were used to present descriptive data. We used chi-squared testing for nominal variables to evaluate differences before and during the COVD-19 pandemic. The odds ratio (OR) values for admission or death were calculated using binominal logistic regression analysis. Data were statistically analyzed using IBM SPSS ver. 27.0 (IBM Corp., Armonk, NY, USA). Statistical significance was set at $P<0.05$.

RESULTS

Participants

In 2019, 48,915 patients visited the emergency medical center, and that number decreased to 38,809 in 2020. Of the 87,724 patients, 87,494 were screened in this study, excluding 230 who visited for purposes other than medical treatment. Among them, the medical records of 479 patients who met the criteria for "self-harm/suicide" were reviewed. Nine patients whose records indicated that they did not attempt suicide were excluded. Because this emergency medical center started running a hyperbaric oxygen treatment center in July 2020, 14 patients from outside the region who were admitted with carbon monoxide poisoning were

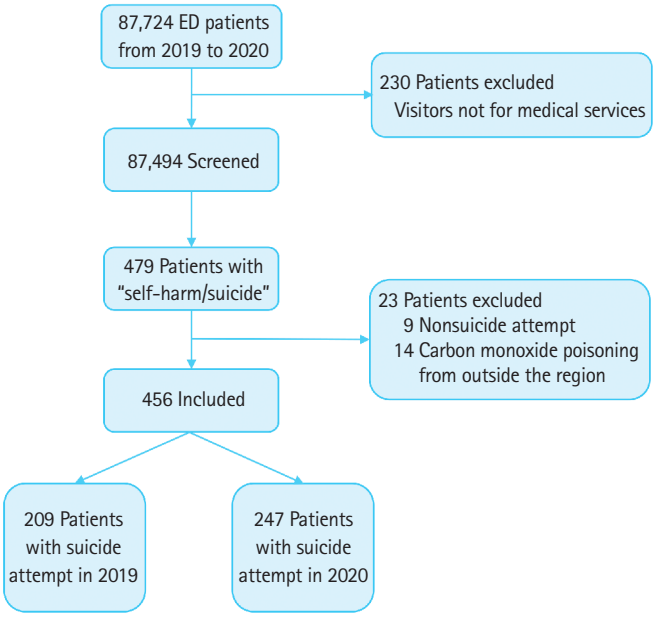

Fig. 1. Study population. ED, emergency department.

excluded. Therefore, 456 patients were included in the analyses (Fig. 1).

Sociodemographic and clinical characteristics

During the COVID-19 pandemic, the total number of patients admitted to the ED decreased by 20.7%. However, the number of patients who visited the ED due to suicide attempts increased from 209 to 247 each year, increasing 18.2% above before-pandemic levels. Additionally, the suicide attempter-to-total ED visit ratio rose from 0.43% to 0.64%, an increase of 48.8% over the before-pandemic levels (P<0.001). Before the COVID-19 pandemic, suicide attempts were most common among people in their 40s and 50s, at 36.8%, whereas during the pandemic, they were most common among those in their 20s and 30s, at 40.1% (Table 1). Among all suicide attempters, 68.2% were in their 20s to 50s. Of the 456 study subjects, 310 (68.0%) were women and 146 (32.0%) were men (Supplementary Table 1). Among women, those in their 20s and 30s accounted for the largest percentage (39.4%), and among men, those in their 40s and 50s accounted for the largest percentage (37.0%).

During the entire period, drug overdose (48.2%) was the most common suicide attempt method, followed by cutting (26.8%), poisoning (including household and industrial materials and pesticides) (9.2%), and gas inhalation (7.2%). There were significant differences in methods of suicide attempt (P=0.001). During the COVID-19 pandemic, drug overdoses increased by 50.0% (from 88 to 132), cutting by 6.8% (from 59 to 63), and gas inhalation by 75% (from 12 to 21). Hanging decreased by 61.5% (from 13 to 5), as did poisoning, 60.0% (from 30 to 12).

Table 1. Demographic and clinical characteristics

Characteristic	2019 (n=209)	2020 (n=247)	Total (n=456)	P-value
Age (yr)				0.251
≤20	35 (16.7)	46 (18.6)	81 (17.8)	
21–40	68 (32.5)	99 (40.1)	167 (36.6)	
41–60	77 (36.8)	67 (27.1)	144 (31.6)	
61–80	24 (11.5)	29 (11.7)	53 (11.6)	
≥81	5 (2.4)	6 (2.4)	11 (2.4)	
Sex				0.827
Female	141 (67.5)	169 (68.4)	310 (68.0)	
Male	68 (32.5)	78 (31.6)	146 (32.0)	
Methods of suicide attempt				0.001
Overdose	88 (42.1)	132 (53.4)	220 (48.2)	
Gas inhalation	12 (5.7)	21 (8.5)	33 (7.2)	
Hanging	13 (6.2)	5 (2.0)	18 (3.9)	
Cutting	59 (28.2)	63 (25.5)	122 (26.8)	
Taking poison	30 (14.4)	12 (4.9)	42 (9.2)	
Idea only	3 (1.4)	7 (2.8)	10 (2.2)	
Jumping	4 (1.9)	7 (2.8)	11 (2.4)	
Health insurance				0.438
National health insurance	193 (92.3)	223 (90.3)	416 (91.2)	
Medical aid	16 (7.7)	24 (9.7)	40 (8.8)	
Endotracheal intubation				0.003
Done	29 (13.9)	14 (5.7)	43 (9.4)	
Not done	180 (86.1)	233 (94.3)	413 (90.6)	
Disposition				0.001
Discharge	117 (56.0)	179 (72.5)	296 (64.9)	
General ward	29 (13.9)	31 (12.6)	60 (13.2)	
Intensive care unit	62 (29.7)	36 (14.6)	98 (21.5)	
Death	1 (0.5)	1 (0.4)	2 (0.4)	

Values are presented as number (%).

Endotracheal intubation was performed in 9.4% of patients, which decreased by 51.7% during the COVID-19 pandemic (P=0.003). As for the disposition of suicide attempters, discharge was the most common at 64.9%, followed by admission to the intensive care unit (21.5%), admission to the general ward (13.2%), and death (0.4%). The number of discharged patients increased by 53.0%, and the number of patients admitted to the intensive care unit decreased by 41.9%, which was strongly correlated with the COVID-19 pandemic (P=0.001).

Of the 456 cases, 173 had insufficient information on sociodemographic characteristics. Of the remaining 283 suicide attempters, 51.6% had a history of suicide attempts, which did not change significantly during the COVID-19 pandemic (Table 2). The number of suicide attempters with a history of mental illness increased by 34.7% during the COVID-19 pandemic (P=0.005). Personal relationships (62.2%) were the most common reasons given for suicide attempts, followed by worsening mental illness

Table 2. Sociodemographic characteristics

Characteristic	2019 (n = 139)	2020 (n = 144)	Total (n = 283)	P-value
Previous attempt				0.586
Presence	74 (53.2)	72 (50.0)	146 (51.6)	
Absence	65 (46.8)	72 (50.0)	137 (48.4)	
Mental illness				0.005
Presence	75 (54.0)	101 (70.1)	176 (62.2)	
Absence	64 (46.0)	43 (29.9)	107 (37.8)	
Cause				0.102
Medical	3 (2.2)	6 (4.2)	9 (3.2)	
Economical	16 (11.5)	19 (13.2)	35 (12.4)	
Relationships	96 (69.1)	80 (55.6)	176 (62.2)	
Worsening mental illness	24 (17.3)	39 (27.1)	63 (22.3)	
Occupation				0.574
Employed	42 (30.2)	48 (33.3)	90 (31.8)	
Unemployed	77 (55.4)	71 (49.3)	148 (52.3)	
Adolescent	20 (14.4)	25 (17.4)	45 (15.9)	
Family				0.768
Live together	112 (80.6)	118 (81.9)	230 (81.3)	
Live alone	27 (19.4)	26 (18.1)	53 (18.7)	

Values are presented as number (%).

(22.3%), economic problems (12.4%), and health problems (3.2%). No significant correlation was observed between any of those reasons and the COVID-19 pandemic. Among the suicide attempters, 52.3% were unemployed, 31.8% were employed, 81.3% lived with their families, and 18.7% lived alone. None of those variables correlated significantly with the COVID-19 pandemic.

Clinical characteristics and their associations with admission or death are shown in in Table 3. Each method showed a significant correlation with admission or death ($P < 0.001$). Hanging (OR, 2.81; 95% confidence interval [CI], 1.05-7.52; $P = 0.041$), taking poison (OR, 3.98; 95% CI, 1.96-8.10; $P < 0.001$), and falling (OR, 3.12; 95% CI, 0.89-11.00; $P = 0.076$) had higher hospitalization rates than the other methods. The hospitalization rate was highest among those in their 60s and 70s (OR, 6.95; 95% CI, 3.07-15.74; $P < 0.001$), and lowest among those younger than 20.

DISCUSSION

Isolation and disconnection are closely related to mental health and are some of the main factors associated with suicide.[11] They include not only the narrow meaning of singleness, divorce, or absence of family or friends but also the broader concepts of loneliness, sense of difference, and lack of social support.[12] During the 2003 severe acute respiratory syndrome epidemic, a study showed that disconnection and isolation were associated with an increase in suicide rates and adverse effects on mental health.[13] The quarantines, social distancing, and lockdowns associated with the COVID-19 pandemic are exacerbating feelings of isolation and disconnection and adversely affecting people's mental health.[14]

Emotional stress is also a significant factor associated with suicidal ideation and suicide. A study of 2,074 students found that depression, anxiety, stress, and despair were important suicide risk factors.[15] A study of 522 teenage patients admitted to an ED in the United Kingdom found that patients reporting recent feelings of anxiety had more than five times the risk of suicide (OR, 5.18) than those who did not.[16] Emotional stress can lead to substance abuse and depression, which can in turn lead individuals to choose suicide as the last way out.[17] The spread of COVID-19 is related to emotional stress.[18]

Economic crises and the suicide rate have also been strongly linked. In a case-control study of 538 people in India during an economic crisis, the suicide rate of the unemployed group was six times higher (OR, 6.15) than that of the employed control group.[19] A nationwide study in the United States reported a strong positive correlation between unemployment and suicide rates during the 2007 to 2009 economic crisis.[20] Such positive correlations tend to appear regardless of the income level of a country. The COVID-19 pandemic is associated with an increase in the unemployment rate and economic crises.[21]

The COVID-19 pandemic appears to cause isolation, disconnection, anxiety, depression, and stress through the various quarantine policies enforced around the world and economic crises. Those changes were expected to affect the causes of suicide attempts, but we found no statistical correlation between the reported causes and the COVID-19 pandemic in this study. The reasons for this finding are as follows: an individual's persistent stress leads to psychiatric disorders such as depression, sleep disorders, and adjustment disorders. Subsequently, the psychiatric disorders progress to the stage of suicidal ideation, and exposure to an impulsive situation with a trigger leads to a suicide attempt. In this study, it is unclear whether the cause given for each suicide attempt was a factor causing persistent stress or an impulsive trigger. We thus attribute our finding of no statistical association with the COVID-19 pandemic to the limitation in determining the detailed causes of suicide attempts.

Similar to previous studies in Korea,[22] 68.2% of the suicide attempters in this study were young or middle-aged. In this study, the male to female ratio was 1:2.1, with the rate of suicide attempts by women more than twice as high as that by men. The intensive care unit admission rate was higher in those older than 60 years ($P = 0.001$), which was similar to previous studies.[23,24] In addition, the most common causes given for suicide attempts were relationships with others (59.3%) and economic problems (22.1%) in men and relationships with others (63.5%) and un-

Table 3. Characteristics according to admission or death

Characteristic	Discharged (n = 296)	Admission or death (n = 160)	P-value[a]	OR (95% CI)	P-value[b]
Age (yr)			< 0.001		
≤ 20	69 (85.2)	12 (14.8)		Reference	
21–40	108 (64.7)	59 (35.3)		3.14 (1.58–6.26)	0.001
41–60	90 (62.5)	54 (37.5)		3.45 (1.71–6.95)	0.001
61–80	24 (45.3)	29 (54.7)		6.95 (3.07–15.74)	< 0.001
≥ 81	5 (45.5)	6 (54.5)		6.90 (1.81–26.24)	0.005
Sex			0.102		
Female	209 (67.4)	101 (32.6)		Reference	
Male	87 (59.6)	59 (40.4)		1.40 (0.93–2.11)	0.103
Methods of suicide attempt			< 0.001		
Overdose	141 (64.1)	79 (35.9)		Reference	
Gas inhalation	17 (51.5)	16 (48.5)		1.68 (0.81–3.51)	0.167
Hanging	7 (38.9)	11 (61.1)		2.81 (1.05–7.52)	0.041
Cutting	106 (86.9)	16 (13.1)		0.27 (0.15–0.49)	< 0.001
Taking poison	13 (31.0)	29 (69.0)		3.98 (1.96–8.10)	< 0.001
Idea only	8 (80.0)	2 (20.0)		0.45 (0.92–2.15)	0.315
Fall	4 (36.4)	7 (63.6)		3.12 (0.89–11.00)	0.076
Health insurance			0.169		
National health insurance	274 (65.9)	142 (34.1)		Reference	
Medical aid	22 (55.0)	18 (45.0)		1.58 (0.82–3.04)	0.172
Previous attempt[c]			0.130		
Presence	102 (69.9)	44 (30.1)		Reference	
Absence	84 (61.3)	53 (38.7)		1.46 (0.89–2.40)	0.131
Mental illness[c]			0.874		
None	58 (65.2)	31 (34.8)		Reference	
Anxiety	21 (67.7)	10 (32.3)		0.89 (0.37–2.13)	0.793
Sleep disorder	5 (83.3)	1 (16.7)		0.37 (0.04–3.35)	0.379
Alcohol dependency	7 (58.3)	5 (41.7)		1.34 (0.39–4.56)	0.643
Depression	83 (66.9)	41 (33.1)		0.92 (0.52–1.64)	0.788
Personality disorder	2 (50.0)	2 (50.0)		1.87 (0.25–13.93)	0.541
Bipolar	9 (64.3)	5 (35.7)		1.04 (0.32–3.37)	0.949
Schizophrenia	1 (33.3)	2 (66.7)		3.74 (0.33–42.92)	0.289
Occupation[c]			0.005		
Employed	57 (63.3)	33 (36.7)		Reference	
Unemployed	90 (60.8)	58 (39.2)		1.11 (0.65–1.91)	0.698
Adolescent	39 (86.7)	6 (13.3)		0.27 (0.10–0.69)	0.007
Family[c]			0.789		
Live together	152 (66.1)	78 (33.9)		Reference	
Live alone	34 (64.2)	19 (35.8)		1.09 (0.58–2.03)	0.789

Values are presented as number (%).
OR, odds ratio; CI, confidence interval.
[a]Chi square test. [b]Binominal logistic regression analysis. [c]Data were available in 283 cases (186 discharged and 97 admission or death).

controlled psychiatric disease (26.9%) in women. Those results are also similar to those in previous research.[25] In a recent study of 6,816 adolescents who visited the ED due to suicidal ideation or a suicide attempt, female youth and adolescents with no previous psychiatric history were reported to be the most vulnerable group.[26] However, in this study, we find patients with a history of mental illness to be the most vulnerable group. During the COVID-19 pandemic, the number of suicide attempts made by people with a history of mental illness increased by 34.7%, which was statistically significant (P = 0.005). We attribute that finding to differences in the representativeness of the sample because the previous study analyzed a large-scale, community-based integrated medical system database, whereas we examined data from a regional emergency medical center with high severity. For ex-

ample, in the previous study, about 3.2% of all ED patients had attempted suicide, whereas in this study, the rate was only 0.5%.

The changes in the methods of suicide attempts before and during the COVID-19 pandemic are interesting. The lethality of suicide attempts varies with the method used. One study reported that poisoning, hanging, jumping, and gas inhalation had high lethality, whereas drug overdoses and cutting had lower lethality.[27] In another study, the case fatality was 83.4% for hanging, 61.5% for gas inhalation, and 60% for jumping, whereas it was only 2.6% for cutting and 2.2% for a drug overdose.[28] In our study, poisoning, hanging, jumping, and gas inhalation, which are highly lethal methods, decreased by 23.7%, whereas drug overdose, cutting, and suicidal ideation, which are less lethal, increased by 32.7% ($P=0.011$). The frequency of intensive care treatment and death by suicide decreased by 41.3%, and the rate of intensive care treatment and death by suicide compared with all suicide attempts also decreased by 50.3%, from 30.2% to 15.0%, during the COVID-19 pandemic.

However, we attribute the increased number of suicide attempters and the decreased lethality of their attempts during the COVID-19 pandemic, specifically the increase in drug overdoses, to changes in accessibility and not sincerity. A study of 30 suicide attempters who used gas inhalation reported that their actual suicidal intention was not high even though they chose a method with high lethality.[29] Another study reported no significant correlation between the degree of suicide sincerity and the results of suicide attempts.[30] One study on drug overdose reported that a drug's toxicity had little effect on drug choice because most suicide attempters had little knowledge about it. The same study reported that committing suicide took less than 30 minutes in more than half of suicide attempters, indicating that the choice is impulsive. Thus, access to drugs and convenience of use greatly influence the drug choices of suicide attempters.[31] The lethality of suicide attempts differs by method, but rather than deliberately choosing a method in consideration of its lethality or prognosis, suicide attempters choose a method impulsively. In other words, accessibility seems to play an important role. In the above-mentioned study on gas inhalation, the suicide attempters reported that accessibility, degree of pain, convenience, and previous media exposure influenced their choice of method.[29]

In this study, patients with a psychiatric history tended to attempt suicide with their psychiatric medications (adjusted OR with age and sex, 2.69; 95% CI, 1.61–4.48; $P<0.001$). This tendency does not reflect low suicidal intention, but easy access to the drugs. For this reason, suicide attempts with low lethality should not be taken lightly.

This study has some limitations. First, as a retrospective study, our information was limited to the medical records. In particular, when the patient was in a coma or their level of consciousness was confused or medically severe, it was difficult to obtain detailed information from them. It is necessary to obtain systematic information about the causes of suicide attempts. Second, if the injury from a suicide attempt was mild, it might be underestimated compared with before the COVID-19 pandemic. During the COVID-19 pandemic, medical resources have been scarce and focused on seriously ill patients.[32] Among those who attempted suicide, those with mild symptoms might have had difficulty accessing medical services. Fear of infection might also have discouraged patients from visiting the ED.[33] A more accurate result could be drawn from a multicenter study that included small and medium-sized emergency medical centers in the region and community mental health care centers. Third, sufficient psychiatric evaluations and interviews were difficult to obtain in the ED because of time and space limitations. In the ED, all patients share an open space with other patients, so in-depth interviews are difficult, and the reliability of interview content is low. In addition, time limitations make psychopathological evaluations difficult, and diagnoses made under the judgment of one psychiatrist can be less accurate than those made by a team. That problem could be overcome by referring patients to a psychiatric outpatient clinic. However, depending on the patient's will for treatment and the awareness of their family, a referral to an outpatient department might not be followed. Therefore, patients with well-established family support should be told about the importance of careful observation by their family and sufficiently educated about the need for continuing treatment through a psychiatric outpatient clinic. For those without such support, it might be helpful to consider hospitalization.

The COVID-19 pandemic is thought to be having an adverse effect on public mental health, so the demand for mental health care will increase. Because the COVID-19 pandemic is likely to be prolonged, mid- to long-term national and clinical measures are needed. First, it is necessary to develop a simple instrument that can evaluate the sincerity, severity, and recurrence probability of suicide attempts. Such a structured instrument could help to select high-risk patients for referral to tertiary hospitals that can provide emergency psychiatric treatment. It would be particularly useful in small to medium-sized EDs that cannot afford full-time specialists to evaluate suicide attempters. Because time and space are limited in the ED, a self-report method with high compliance and reliability will be useful, so long as no significant difference is found between it and the clinician-reported method.[34] In addition, a previous study reported that postmanagement through a mental health care center after a suicide attempt significantly lowered the suicide rate. Therefore, it is important to refer patients

to a community mental health care center after discharge.[35] Suicide attempters should be registered and managed on a follow-up list, and access to a 24-hour suicide crisis telephone counseling service should be provided.

In summary, this study compared the sociodemographic and clinical characteristics of suicide attempters who visited an ED before and during the COVID-19 pandemic. The study showed that during the COVID-19 pandemic, suicide attempts have increased in the ED although the lethality of many attempts is low. These findings suggest that interventions including preventive measures for suicide attempts, screening of high-risk patients, and a post-management process for patients with mental health problems are needed.

SUPPLEMENTARY MATIERAL

Supplementary Table 1. Demographic and clinical characteristics
Supplementary material is available from: https://doi.org/10.15441/ceem.21.088.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Original Article

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The effect of COVID-19 pandemic on the length of stay and outcomes in the emergency department

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Objective This study aimed to evaluate the change in length of stay (LOS) in the emergency department (ED) and outcomes during the coronavirus disease 2019 (COVID-19) pandemic.

Methods This is a single-center, retrospective observational study. We compared ED LOS and outcomes in patients aged ≥19 years who presented to the ED of Soonchunhyang University Bucheon Hospital, a single tertiary university hospital, between January and December in 2018, 2019, and 2020. We included patients who were diagnosed with fever, pneumonia, and sepsis in the ED, based on the International Statistical Classification of Diseases and Related Health Problems 10th Revision. We also compared the LOS and outcomes of overall ED patients in 2019 (before COVID-19) and in 2020 (after COVID-19).

Results A total of 5,061 patients with fever, pneumonia, and sepsis were analyzed. The LOS in the ED in 2020 significantly increased compared with 2018 and 2019 (177.0±115.0 minutes in 2018, 154.0±85.0 minutes in 2019, and 208.0±239.0 minutes in 2020). The proportion of patients who were transferred to other hospitals in 2020 (2.1%) increased compared with 2018 (0.8%) and 2019 (0.7%). Intensive care unit admission significantly increased in 2020 (13.7%) compared with 2019 (10.3%). Among all ED patients, ED LOS in 2020 was longer than in 2019, particularly in patients who were admitted and then transferred to another hospital. Intensive care unit admission (4.4% vs. 5.0%), transfer rate (0.7% vs. 0.9%), and ED mortality (0.6% vs. 0.7%) also significantly increased.

Conclusion The ED LOS, time to intensive care unit admissions, time to transfer to other hospitals, and ED mortality significantly increased during the COVID-19 pandemic.

Keywords COVID-19; Emergencies; Crowding; Length of stay

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Capsule Summary

What is already known

The coronavirus disease 2019 (COVID-19) pandemic is a global crisis that may adversely affect the emergency department (ED) process for patient care.

What is new in the current study

This study showed that the length of stay in the ED, time to intensive care unit admission, and time to transfer to other hospitals significantly increased during the COVID-19 pandemic compared with the prior years among patients with fever, pneumonia, and sepsis according to the diagnosis code. The mortality in the ED also increased along with the length of stay, transfer, and intensive care unit admission in the total ED patients during the COVID-19 pandemic.

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INTRODUCTION

In December 2019, cases of pneumonia with an unknown cause were first reported in Wuhan, Hubei Province, China, which had by then spread globally. The World Health Organization termed the condition as coronavirus disease 2019 (COVID-19), which is caused by severe acute respiratory syndrome coronavirus 2. COVID-19 involves nonspecific symptoms, including fever, dry cough, and discomfort. COVID-19 pneumonia causes severe dyspnea, and patients have high rates of transition to intensive care and mortality.[1-5]

As the safety net of the healthcare system, the emergency department (ED) is responsible for managing the large influx of patients affected by the pandemic. With the spread of COVID-19, the work routine in the ED has changed remarkably.[6-14] The COVID-19 pandemic affected not only quality of care, safety, patient-centeredness, timeliness, efficiency, effectiveness, and equity, but also objective clinical endpoints such as mortality in the ED. The ED process for patients with fever or suspected infection that need to be differentiated from COVID-19 or quarantined may be further affected. Information on ED admission patterns, length of stay (LOS), and mortality is important to determine ED policies and allocate medical resources in an effective way during a pandemic of an infectious disease like COVID-19.

The aim of the study was to evaluate the change in ED LOS and outcomes including ED disposition and ED mortality during the COVID-19 pandemic compared with the prior years. We compared the outcomes in patients with fever, pneumonia, and sepsis, and investigated all ED patients.

METHODS

This study was a retrospective cross-sectional study. Ethical approval was obtained from the institutional review board of Soonchunhyang University Bucheon Hospital (No. 2020-11-023-001). Informed consent was waived due to the retrospective nature of the study. The patients included in this study were admitted to the ED of a single tertiary university between January 1st and December 31st in 2018, 2019, and 2020. We included patients who were diagnosed with fever, pneumonia, and sepsis in the ED during the corresponding period from 2018 to 2020. Fever, pneumonia, and sepsis were defined based on the International Statistical Classification of Diseases and Related Health Problems 10th Revision, Clinical Modification (ICD-10 CM) codes R50.9, R50.99, R57.2, J12.9, J15.9, J18.9, and A41.9. In addition, we compared the LOS and disposition of all ED patients between 2019 (before the COVID-19 period) and 2020 (after the COVID-19 period). We excluded patients aged < 19 years.

From the electronic medical records, data on demographics, chief complaints, disposition of the patients, and LOS in the ED were collected. We also investigated ED mortality, admission, in-hospital arrest in the ED, and the rate of intensive care unit (ICU) admission. The primary outcome was the ED LOS, and secondary outcomes were time to ICU admission, time to transfer to another hospital, and ED mortality.

All statistical analyses were performed using the R ver. 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria). We conducted frequency analysis to identify the subjects' characteristics. Nominal variables are presented as counts and percentages of

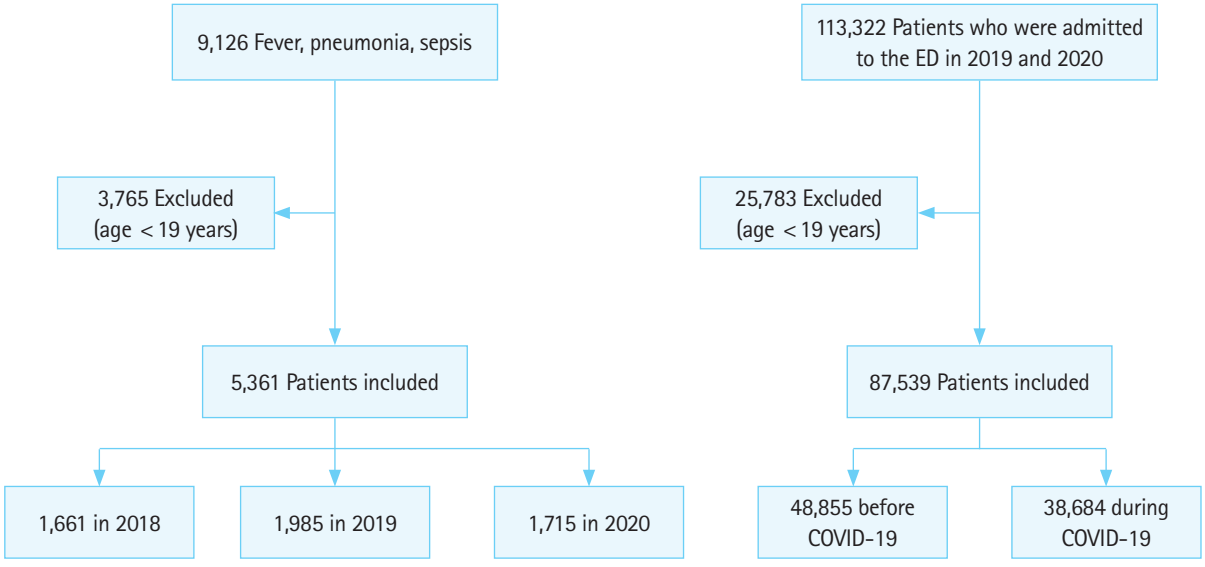

Fig. 1. Study population. ED, emergency department; COVID-19, coronavirus disease 2019.

total numbers. Data of continuous variables with normal distribution are presented as mean and standard deviation. All variables were compared using the chi-square test and analysis of variance at a significance level of $P<0.05$. Post hoc test was performed using the Tukey test. We constructed boxplots to compare the LOS in the ED between patients who were admitted and those who were discharged.

RESULTS

In this study, a total of 5,361 patients with the ICD-10 CM codes of fever (n = 1,661), pneumonia (n = 1,985), and sepsis (n = 1,715) were included between February and June in 2018, 2019, and 2020 (Fig. 1). Table 1 shows patients' demographics, diagnosis, visit route, disposition, and LOS in the ED. The mean age was 61.0 ± 19.0 years in 2018, 55.0 ± 20.0 years in 2019, and 62.0 ± 17.0 years in 2020 ($P<0.001$). The proportion of patients with fever in 2020 (60.0%) was higher than in 2018 (54.4%), but similar to 2019 (60.0%). The proportion of patients with pneumonia in 2020 (31.8%) decreased compared with 2018 (41.1%). Regarding the visit route to the ED, the proportion of patients from the outpatient department decreased in 2020 (0.5%) compared with 2018 (2.0%) and 2019 (1.2%). Transferred patients from other hospitals also decreased in 2020 (18.5%) compared with 2018 (14.5%). ICU admission significantly increased in 2020 (13.7%) compared with 2019 (10.3%). The proportion of patients who were transferred to other hospitals at the ED in 2020 (2.1%) increased compared with 2018 (0.8%) and 2019 (0.7%). There was no significant change in the ED mortality. The LOS in the ED in 2020 significantly increased compared with 2018 and 2019 (177.0 ± 115.0 minutes in 2018, 154.0 ± 85.0 minutes in 2019, and 208.0 ± 239.0 minutes in 2020).

Fig. 2 shows the annual change of LOS in the ED according to the patients' disposition at the ED. There was no significant change in LOS in 2020 among the discharged patients (129.9 ± 92.6 minutes in 2018, 117.5 ± 78.4 minutes in 2019, and 124.9 ± 121.6 minutes in 2020). Among patients who were admitted or transferred or who expired, LOS in 2020 significantly increased compared with that in 2018 and 2019 (356.0 ± 303.7 minutes in 2018, 292.5 ± 214.7 minutes in 2019, and 546.0 ± 398.7 minutes in 2020).

LOS in the ED by diagnosis is detailed in Table 2. In patients with pneumonia and sepsis, LOS in 2020 significantly increased compared with 2018 and 2019 (LOS of patients with pneumonia, 253.0 ± 101.0 minutes in 2018, 220.5 ± 57.5 minutes in 2019, and 416.0 ± 150.5 minutes in 2020; LOS patients with sepsis, 264.0 ± 86.0 minutes in 2018, 281.0 ± 93.0 minutes in 2019, and 447.0 ± 198.5 minutes in 2020).

Among all ED patients, ED LOS during the COVID-19 pandemic in 2020 was longer than that before the COVID-19 pandemic in 2019, particularly in patients who were admitted (235.0 ± 91.0 minutes vs. 274.0 ± 146.0 minutes, $P<0.001$) and who were transferred to another hospital (213.0 ± 93.5 vs. 255.0 ± 162.5, $P<0.001$) (Table 3). ICU admission (4.4% vs. 5.0%, $P<0.001$) and transfer

Table 1. Comparisons of baseline characteristics

Characteristic	2018 (n = 1,661)	2019 (n = 1,985)	2020 (n = 1,715)	P-value
Age (yr)	61.0 ± 19.0	55.0 ± 20.0	62.0 ± 17.0	< 0.001[a]
Male sex	821 (49.4)	982 (49.5)	828 (48.3)	0.726
ICD code				
Fever	904 (54.4)	1,270 (64.0)	1,029 (60.0)	< 0.001[a,b]
Pneumonia	683 (41.1)	608 (30.6)	563 (32.8)	< 0.001[b]
Sepsis	74 (4.5)	107 (5.4)	123 (7.2)	0.002
Visit route				
Direct visit	1,321 (79.5)	1,682 (84.7)	1,458 (85.0)	< 0.001[b]
Transfer	307 (18.5)	280 (14.1)	249 (14.5)	< 0.001[b]
Outpatient	33 (2.0)	23 (1.2)	8 (0.5)	< 0.001[a,b]
ED disposition				
Discharge	853 (51.3)	1,154 (58.1)	922 (53.7)	< 0.001[a]
Admission	778 (46.9)	814 (41.0)	748 (43.6)	0.002[a,b]
ICU	209 (12.6)	205 (10.3)	235 (13.7)	0.005[a]
Transfer	14 (0.8)	13 (0.7)	36 (2.1)	< 0.001[a,b]
Death	16 (1.0)	4 (0.2)	9 (0.5)	0.008
ED LOS (min)	177.0 ± 115.0	154.0 ± 85.0	208.0 ± 239.0	< 0.001[a,b]

Values are presented as number (%) or mean ± standard deviation.
ICD, International Classification of Diseases; ED, emergency department; ICU, intensive care unit; LOS, length of stay.
[a]$P<0.05$ compared between 2019 and 2020. [b]$P<0.05$ compared between 2018 and 2020.

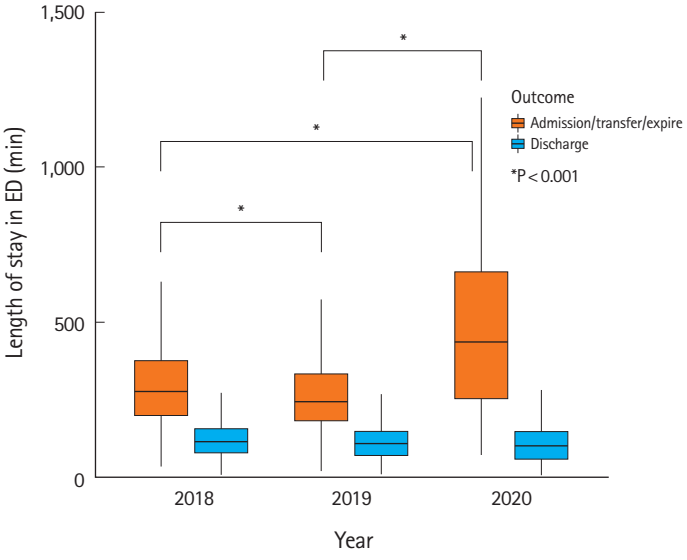

Fig. 2. Box plot of the length of stay in the emergency department (ED) according to disposition.

Table 2. Comparisons of LOS and outcomes in patients with fever, pneumonia, and sepsis

Variable	Fever				Pneumonia				Sepsis			
	2018 (n=904)	2019 (n=1,270)	2020 (n=1,029)	P-value	2018 (n=683)	2019 (n=608)	2020 (n=563)	P-value	2018 (n=74)	2019 (n=107)	2020 (n=123)	P-value
ED LOS (min)	127.0±56.0	179.0±56.0	212.0±86.0	0.412[a]	253.0±101.0	220.5±57.5	416.0±150.5	<0.001[a,b]	264.0±86.0	281.0±93.0	447.0±198.5	<0.001[a,b]
Disposition				0.909				0.051				0.476
Discharge	750 (83.1)	1,062 (83.6)	861 (83.8)		101 (14.8)	91 (15.0)	60 (10.7)		1 (1.4)	1 (0.9)	0 (0)	
Nondischarge	153 (16.9)	208 (16.4)	167 (16.2)		582 (85.2)	517 (85.0)	503 (89.3)		73 (98.6)	106 (99.1)	123 (100)	

Values are presented as mean±standard deviation or number (%).
LOS, length of stay; ED, emergency department.
[a]P<0.05 compared between 2018 and 2020. [b]P<0.05 compared between 2019 and 2020.

Table 3. Comparison of outcomes of all patients in the emergency department between 2019 and 2020

Outcome	2019[a] (n=48,855)	2020[b] (n=38,684)	P-value
ED length of stay (min)			
All patients	120.0±46.0	125.0±52.0	<0.001
Admission	235.0±91.0	274.0±146.0	<0.001
Discharge	102.0±44.0	102.0±47.0	0.767
Transfer	213.0±93.5	255.0±162.5	<0.001
Disposition			
Admission	11,295 (23.1)	9,870 (25.5)	<0.001
ICU admission	2,138 (4.4)	1,928 (5.0)	<0.001
Transfer	348 (0.7)	339 (0.9)	0.008
Cardiac arrest in the ED	102 (0.2)	84 (0.2)	0.859
ED mortality rate	284 (0.6)	285 (0.7)	0.006

Values are presented as mean±standard deviation or number (%).
ED, emergency department; ICU, intensive care unit.
[a]Before coronavirus disease 2019. [b]After coronavirus disease 2019.

rate (0.7% vs. 0.9%, P=0.008) increased in 2020 compared with 2019. The in-hospital arrest rate in the ED was not different, but ED mortality in 2020 was significantly higher than that in 2019 (0.7% and 0.6%, respectively, P=0.006).

DISCUSSION

This study showed that ED LOS, ICU admission, and transfer to other hospitals significantly increased during the COVID-19 pandemic in 2020 compared with the prior years among patients with fever, pneumonia, and sepsis according to the ED diagnosis of ICD-10 CM code. We also observed that ED mortality worsened along with other outcomes in overall ED patients during the COVID-19 period.

We suggest that the increase in LOS might be due to evaluation of the COVID-19 test results before making a decision on admission. Once the COVID-19 pandemic began, the reverse transcription-polymerase chain reaction (RT-PCR) test was performed in patients who had fever or respiratory symptoms. If the patients had pneumonia or no clear focus for fever, the patients were admitted to the general ward after a negative COVID-19 RT-PCR test result. If the test confirmed that the patient was COVID-19 positive, they would be admitted to a specialized hospital designated for COVID-19. In our hospital, we performed abdomen pelvis computed tomography or chest computed tomography to clarify the source of infection depending on signs indicating viral pneumonia on chest radiography. In pneumonia and sepsis cases, the LOS in the ED was relatively longer because the decision to admit or transfer needed to be made. Patients could not be admitted until the COVID-19 test results were obtained. In our

study, a comparison of the LOS in the ED between discharged and non-discharged patients indicated a slight difference in the LOS in the ED for discharged patients, but the LOS in the ED significantly increased for non-discharged patients. Similar to the results of this study, Sun et al.[15] suggested that the COVID-19 pandemic has led to an increase in the LOS in the ED for admitted or transferred patients and had increased ED crowding.

As with the previous avian influenza A and severe acute respiratory syndrome (SARS) pandemics, preventing ED crowding has become an important issue. During SARS, patients were classified into appropriate places through websites or call centers, and standardized ED hospitalization criteria were identified for patients with respiratory symptoms. Restricting the influx of patients can be accomplished by triage points before and upon ED arrival. While few patients who had avian influenza A or SARS will ultimately require hospital-based care, many of them can be counseled and/or tested in an outpatient setting, which is similar to what was observed in our study. At the hospital, diverting low-risk patients with respiratory symptoms to an alternate site of care, such as a medical tent, may be a useful strategy to prevent ED crowding and worsening of ED LOS.[16,17]

A rapid test for COVID-19 in the ED would probably reduce the LOS in the ED.[18] Other COVID-19 tests, such as the COVID-19 immunoglobulin M and immunoglobulin G rapid test lateral flow immunoassay performed in the ED of a tertiary hospital in northern Italy, were designed to provide rapid diagnosis. However, this test is not recommended because it can result in misdiagnosis of the disease owing to a poor sensitivity of $<20\%$.[19,20] COVID-19 testing is currently performed using the RT-PCR test, which takes a longer time. A more efficient COVID-19 testing may be needed and increasing the frequency of COVID-19 testing may be an effective way to reduce the time to obtain the results. Furthermore, creating a ward for cohort isolation, so that patients without COVID-19 results can wait, may be another alternative. Patients who do not have COVID-19 test results can be moved to the infection ward and when the test results are available, they can be moved to their final ward.[21]

In addition to the time taken in the screening process for COVID-19, there are other factors that have increased the ED LOS and crowding. First, to treat infected patients and block spreading of infectious diseases, we quarantined them and asked them to put on personal protective equipment. In the case of our hospital, the clinic is divided into general treatment rooms, screening rooms, and negative pressure isolation rooms. The time for patient examination in the screening room was relatively longer than that in the negative pressure isolation room. Second, as the COVID-19 pandemic continued, medical staff could not avoid exposure to COVID-19 infection. The self-isolation of exposed medical staff may increase the burden of fellow medical staff. In our ED, according to the physician's duty schedule, if one doctor self-isolated, the mean working hours per week increased by 8 hours, and when two doctors self-isolated at the same time, the mean working hours per week increased by 18 hours. Third, problems of cooperation with other departments led to an increased burden on the ED. As the COVID-19 pandemic continued, other departments also lacked human resources. Thus, they were unable to manage their patients in the ED waiting for admission, which increased the ED workload. Fourth, delay in ICU admission may have impaired the quality of care in ED due to increased ED crowding and workload.

This study has several limitations. First, we could not confirm whether the quality of ED care was impaired and whether the ED crowding worsened during the COVID-19 pandemic. We did not use direct indicators such as loading of ED index, crowdedness index, emergency care workload unit, the Emergency Department Work Index, the National ED Overcrowding Scale, or the Real-time Emergency Analysis of Demand Indicator to determine whether there was an increase in workload in the ED due to the COVID-19 pandemic.[22-24] Second, as we performed this study retrospectively at a single center, it cannot represent the ED care process of most patients at other hospitals. Third, patients with different disease codes may have been excluded because our study targeted only patients with respiratory diseases and fever.

In conclusion, this single-center study showed that ED LOS, ICU admission, and transfer to other hospitals significantly increased during the COVID-19 pandemic among patients with fever, pneumonia, and sepsis. In addition, ED mortality worsened along with other outcomes in overall ED patients during the COVID-19 pandemic.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Original Article

The relationship between abnormal intracranial findings in brain computed tomography and antiplatelet or anticoagulant use in patients with nontraumatic headache: a prospective cohort study

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Objective This study aimed to investigate the relationship between abnormal intracranial findings on brain computed tomography and antiplatelet or anticoagulant use in patients with nontraumatic headache in the emergency department (ED).

Methods This was a single-center prospective observational study of patients admitted to the tertiary ED with complaints of nontraumatic headache between May 1, 2016 and September 1, 2016. Anticoagulant or antiplatelet drug use by the patient was recorded. Brain computed tomography (CT) results were categorized into two groups, abnormal results (CT positive) and no pathologic results (CT negative), and compared. The CT positive group included any pathological signs in the brain and the negative group was considered a normal read. A logistic regression analysis was used for evaluating the association of antiplatelets and anticoagulants with abnormal CT findings.

Results Of the 837 patients with nontraumatic headaches, 157 (18.8%) patients who underwent brain CT scanning were included. The mean age of the patients was 44.4±16.7 years. Eighty-eight (56.1%) of the patients were women. Of the 29 (18.4%) patients using antiplatelets or anticoagulants, 16 (55.2%) were in the CT positive group. There was a statistically significant difference between both groups in terms of drug use compared to the CT negative group ($P<0.001$). Factors affecting CT results were examined in logistic regression analysis and a statistically significant difference was found in the detection of positive results in antiplatelet or anticoagulant drug users (adjusted odds ratio, 2.478; 95% confidence interval, 1.006–6.102; $P=0.048$).

Conclusion The use of antiplatelets or anticoagulants in patients admitted to the ED with nontraumatic headache is associated with an increased risk of abnormal intracranial results in brain CT.

Keywords Nontraumatic headache; Emergency service; Antiplatelets; Anticoagulants

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Capsule Summary

What is already known

The approach to nontraumatic headache in the emergency department is focused on recognizing those at risk of rapid deterioration, morbidity, and mortality. Noncontrast computed tomography is used to quickly recognize high-risk headache situations in the emergency department.

What is new in the current study

We found that the use of antiplatelets or anticoagulants in patients admitted to the emergency department with nontraumatic headache is significantly associated with abnormal intracranial results on brain computed tomography.

INTRODUCTION

Patients with nontraumatic headaches have an important place in emergency room admissions.[1] There are primary headaches such as migraine, tension-type, cluster-type, as well as secondary headaches that occur due to a specific cause when examined.[2] The approach for nontraumatic headaches in the emergency department (ED) focuses mostly on recognizing those at risk of rapid deterioration, morbidity, and mortality among patients with headaches. Thus, it is important to quickly recognize high-risk headache situations in the ED and to offer appropriate treatment. Benign conditions constitute the majority of causes when the etiology of patients with nontraumatic headache is examined.[3] The first step in headache management is to identify high-risk situations. For headaches, it accounts for only 4% of high-risk headaches, but 10% to 14% of sudden onset headaches are thunderclap headaches.[4,5] Thunderclap headache requires urgent and detailed evaluation because it is associated with intracerebral aneurysm leakage (sentinel hemorrhage or suspected bleeding).

Antiplatelets and anticoagulants are commonly used in treating or in the prophylaxis of many diseases in recent years. Patients using these drugs have been known to have increased risk of intracranial injury after head trauma and worsening clinical outcomes.[6] Consequently, the risk of nontraumatic headaches due to intracranial hemorrhages (ICHs) caused by antiplatelet and anticoagulant therapy has also increased in recent years.[7] There is insufficient information on the indications in neurological imaging associated with the use of these drugs in patients admitted to the ED with nontraumatic headaches in the literature. Therefore, neurological imaging methods in the ED should reconsider excluding the underlying life-threatening conditions in patients presenting with nontraumatic headaches.[8] Noncontrast computed tomography (CT) is the most appropriate and fastest initial imaging examination in patients presenting to the ED with headache, and are the most sensitive in detecting acute ICH.[9-11] This study aims to investigate the association of antiplatelet or anticoagulant use on brain CT findings in patients admitted to the ED with nontraumatic headache.

METHODS

Study design and setting

This was a single-center prospective observational study. Patients admitted to the ED of a tertiary university hospital with nontraumatic headaches were included. Brain CT results with and without hemorrhage findings were compared. Ethics committee approval was obtained from the ethics committee of Akdeniz University School of Medicine (No. 30.11.2016/617). Written informed consent was obtained from the patients and/or their family members.

Selection of participants

Patients > 18 years of age admitted to the ED with complaints of nontraumatic headache between May 1, 2016 and September 1, 2016 were included in the study. Patients ≤ 18 years of age and with a history of head trauma within the last 3 weeks were excluded. Headaches were classified according to the International Classification of Headache Disorders before brain CT was performed.[2] Ordering of an emergent brain CT was determined by the emergency physician based on the patient's examination and international guidelines.[9]

Data collection and processing

Triage staff and research assistants were trained on the study protocols and collected medical, clinical, and sociodemographic data of the patients in the standardized data form prior to CT. Anticoagulant and/or antiplatelet drug use by the patient was determined by the medical history and the Medula drug inquiry system. Patients with nontraumatic headaches were categorized according to brain CT indication after initial evaluation by the emergency physician. All brain CT images were reported by different radiologists with expertise in the field, and the results were

Table 1. Baseline characteristics of patients

Characteristic	Nontraumatic headache with brain CT (n = 157)
Age (yr)	44.4 ± 16.7
Sex	
Male	69 (43.9)
Female	88 (56.1)
Presenting headache diagnosis	
Migraine	39 (24.8)
Tension-type headache	45 (28.7)
Cluster headache	10 (6.4)
Other primary headache	23 (14.8)
Secondary headaches	40 (25.5)
Antiplatelets or anticoagulants	29 (18.5)
Platelets, $10^3/\mu L$	238.6 ± 64.5
International normalized ratio	2.03 ± 0.86
Brain CT results	
Abnormal results	
Subdural hematoma	3 (1.9)
Subarachnoid hemorrhage	2 (1.3)
Hydrocephalus	7 (4.5)
Chronic ischemia	18 (11.5)
Mass	11 (7.0)
Sinusitis	12 (7.6)
Normal results	104 (66.2)
Discharged from ED	134 (85.4)
Hospitalized	23 (14.6)

Values are presented as mean ± standard deviation or number (%).
CT, computed tomography; ED, emergency department.

recorded. Brain CT results were categorized into two groups, abnormal results (CT positive) and no abnormal results (CT negative), and compared. The CT positive group included patients who had any pathological signs on the brain CT and the negative group was considered as patients with a normal result (Table 1).

Statistical analysis

Data analysis was conducted using IBM SPSS Statistics ver. 20.0 (IBM Corp., Armonk, NY, USA). Categorical data were expressed as numbers and percentages and continuous variables were expressed as means and standard deviations. Chi-square test was used to compare categorical variables and the McNemar test was used for continuous data. A logistic regression analysis was performed to examine the association of independent variables with brain CT. A P-value less than 0.05 was considered significant.

RESULTS

Between May 1, 2016 and September 1, 2016, 866 patients with headaches admitted to the ED were examined (Fig. 1) We included 837 patients in the study after 29 patients were excluded due

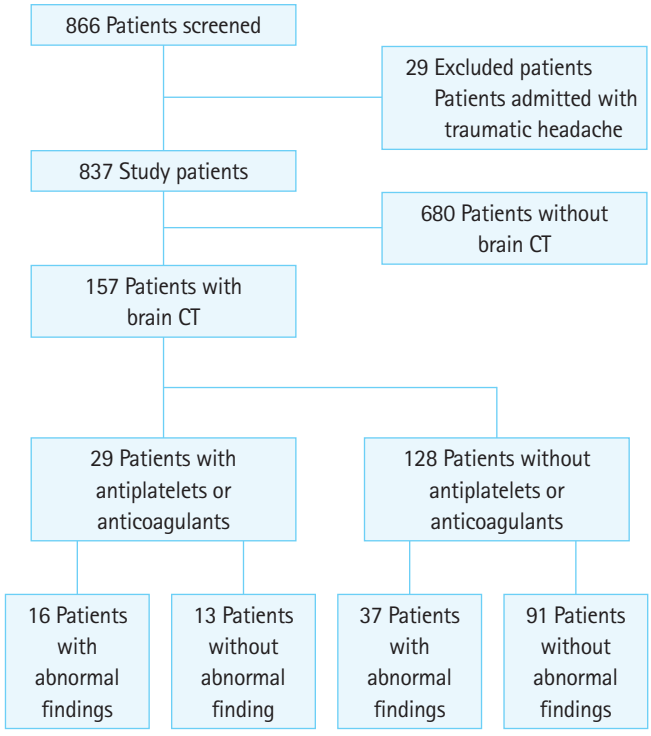

Fig. 1. Study flow chart.

to history of head trauma within the last three weeks. Of the patients included, 537 (63.4%) were female. The patient mean age was 40.2 years, and the median age was 38.0 years. Sixty-seven of these patients were using antiplatelets or anticoagulants. Of those 67 patients (8.0%), 28 were using aspirin, eight were using clopidogrel, two were using low molecular weight heparin, one was using unfractionated heparin, 11 were using warfarin, three were using a new generation of anticoagulants (two were using rivaroxaban, one was using apixaban), six were using aspirin+clopidogrel, three were using aspirin+warfarin, one was using low molecular weight heparin+warfarin, one was using aspirin+ticagrelor, and two were using aspirin+unfractionated heparin. Brain CT was requested for 128 of patients not using antiplatelets or anticoagulants and 29 of patients using these drugs. Of the 837 patients, 157 (18.8%) underwent brain CT scanning upon direction of an emergency physician (Fig. 1). Patients who had brain CT scanning were then analyzed. The mean age of these patients was 44.4 ± 16.7 years. Among them, 88 patients (56.1%) were female. There were 39 patients (24.8%) with migraine headache, 45 (28.7%) with tension headache, 10 (6.4%) with cluster headache, 23 patients (14.8%) classified with other primary headaches, and 40 (25.5%) were classified as secondary headache (Table 1). Of the patients screened for brain CT with the decision of an emergency physician, 29 (18.4%) were using antiplatelets or anticoagulants. ICH was detected in two patients (0.01%) who

Table 2. The association of antiplatelet or anticoagulant drug therapy with imaging results and discharge

Variable	Total (n = 157)	CT positive (n = 53)	CT negative (n = 104)	P-value
Antiplatelets or anticoagulants therapy	29 (18.5)	16 (30.2)	13 (12.5)	< 0.001
Without antiplatelets or anticoagulants therapy	128 (81.5)	37 (69.8)	91 (87.5)	< 0.001
Discharged from ED	134 (85.4)	34 (64.2)	100 (96.2)	< 0.001
Hospitalized	23 (14.6)	19 (35.8)	4 (3.8)	0.125

Values are presented as number (%).
CT, computed tomography; ED, emergency department.

Table 3. Logisitic regression analysis of risk factors associated with abnormal CT results

Variable related to CT results	OR	95% CI	P-value
Antiplatelets or anticoagulants therapy	2.478	1.006–6.102	0.048
Presenting headache diagnosis			
Migraine		Reference	
Tension type headache	1.165	0.429–3.162	0.764
Cluster headache	0.697	0.122–3.978	0.685
Other primary headache	0.851	0.240–3.014	0.803
Secondary headaches	2.423	0.884–6.643	0.086
Sex, female vs. male	2.624	1.286–5.353	0.080

CT, computed tomography; OR, odds ratio; CI, confidence interval.

were not using these drugs and three patients (0.10%) who were using these drugs. We discharged 134 patients (85.4%) and 23 (14.6%) were hospitalized after brain CT.

The association of antiplatelets or anticoagulants with CT results, hospitalization, and discharge was examined. Of the 29 patients using antiplatelets or anticoagulants, 16 (55.2%) were in the CT positive group. Of the 128 patients without antiplatelets or anticoagulants, 37 (28.9%) were CT positive. There was a statistically significant difference between both groups in terms of drug use ($P < 0.001$) (Table 2). Regarding the patients' disposition, 100 patients (96.2%) in the CT negative group and 34 (64.2%) in the CT positive group were discharged from the ED ($P < 0.001$). Factors associated with CT results were examined in logistic regression analysis and a statistically significant association was found between the detection of positive results and antiplatelet or anticoagulant drug use (odds ratio, 2.478; 95% confidence interval, 1.003–6.102; $P = 0.048$) (Table 3).

DISCUSSION

Antiplatelet and anticoagulant drugs are commonly used in diseases such as coronary artery disease, heart failure, atrial fibrillation, and stroke.[12] Previous studies have shown the efficacy of these drugs, and their side effects and risks have been discussed. The ICH rates were found to be similar in patients receiving aspirin or clopidogrel (0.2% vs. 0.4%) in the clopidogrel versus aspirin in patients at risk of ischaemic events (CAPRIE), African American Antiplatelet Stroke Prevention Study (AASPS), and management of atherothrombosis with clopidogrel in high-risk patients (MATCH) studies.[13] In addition, the incidence of ICH was 0.3% in patients using aspirin or aspirin+clopidogrel in the Clopidogrel for High Atherothrombotic Risk and Ischemic Stabilization, Management, and Avoidance (CHARISMA) study.[14] ICH was reported in 0.10% of patients admitted with headaches that underwent brain CT or used antiplatelets or anticoagulants in our study.

De Bonis et al.[15] investigated the association of antiplatelet/anticoagulant use with chronic subdural hematoma in the elderly patient population. Both anticoagulant and antiplatelet use were found to significantly increase the risk of chronic subdural hematoma. Furthermore, Gaist et al.[16] reported that antithrombotic use increased from 31.0 per 1,000 individuals from the general population in the year 2000 to 76.9 per 1,000 individuals in 2015. Out of 10,010 patients with subdural hematoma, 43.7% were shown to be using antithrombotic drugs. Low dose aspirin, clopidogrel, and oral anticoagulants were reported to have an increased risk of subdural hematoma in the same study. The use of antiplatelets/anticoagulants was not included as an indication of neuroimaging in nontraumatic headache patients admitted to the ED in the guidelines published by the American College of Radiology.[17] However, their use has been shown to be a risk factor for spontaneous ICH and chronic subdural hematoma in most studies.[15,16]

There were not enough studies in the literature investigating the neuroimaging relationship in nontraumatic headaches using anticoagulant/antiplatelet drugs when we conducted this study. A recent study on neuroradiological results and etiology in nontraumatic headaches in the ED examined 1,132 nontraumatic headache patients and neuroimaging was performed in 303 patients and an intracranial anomaly was detected in 70 (23.1%) of the patients who underwent imaging.[18] Similarly, brain CT was not performed in more than half of our patient population in our study. However, it is noted that emergency physicians are more likely to perform brain CT (43.3% vs. 16.8%) if the patient has a history of antiplatelet/anticoagulant use. Out of 1,275 secondary nontraumatic headaches, 369 (28.9%) underwent CT scanning and 47 (12.7%) had intracranial pathological results within a 6-month period in another study on the application of computerized decision support systems for the indication of brain CT scanning for nontraumatic headaches in the ED.[19] The rate of CT positive rate among patients using antiplatelet/anticoagulant drugs

was 16 (55.2%) in our study. The high rate of pathological results found in our study suggests a relationship between antiplatelet/anticoagulant drug use and CT scanning in nontraumatic headaches in the ED.

The present study has limitations. First, this was a single-center study. Second, brain CT could not be performed on all nontraumatic headache patients included in the study. This limitation suggests that there may have been abnormal intracranial results in patients without CT scan. All brain CT images were reported by different radiologists, so this may have affected the results. Additionally, brain CT decision-making was not always determined by the same physician. Multicenter prospective studies are required with larger patient groups with nontraumatic headaches using anticoagulants or antiplatelets in the ED.

The use of antiplatelets or anticoagulants in patients admitted to the ED with nontraumatic headaches are associated with increased risk of abnormal intracranial results on brain CT. It will be beneficial to include this group of drugs in neuroimaging indications in nontraumatic headache patients.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Study Protocol

Finding acute coronary syndrome with serial troponin testing for rapid assessment of cardiac ischemic symptoms (FAST-TRAC): a study protocol

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Objective To determine the utility of a highly sensitive troponin assay when utilized in the emergency department.

Methods The FAST-TRAC study prospectively enrolled >1,500 emergency department patients with suspected acute coronary syndrome within 6 hours of symptom onset and 2 hours of emergency department presentation. It has several unique features that are not found in the majority of studies evaluating troponin. These include a very early presenting population in whom prospective data collection of risk score parameters and the physician's clinical impression of the probability of acute coronary syndrome before any troponin data were available. Furthermore, two gold standard diagnostic definitions were determined by a pair of cardiologists reviewing two separate data sets; one that included all local troponin testing results and a second that excluded troponin testing so that diagnosis was based solely on clinical grounds. By this method, a statistically valid head-to-head comparison of contemporary and high sensitivity troponin testing is obtainable. Finally, because of a significant delay in sample processing, a unique ability to define the molecular stability of various troponin assays is possible.

Trial registration ClinicalTrials.gov Identifier NCT00880802

Keywords Acute coronary syndrome; Troponin; Emergency medicine; Myocardial infarction; Coronary artery disease

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Capsule Summary

What is already known

High sensitivity troponin is an excellent predictor of adverse events in emergency department patients.

What is new in the current study

This is one of the very few investigations to not use local troponin results to define the gold standard diagnosis (by having a nontroponin independent comparator), it required enrollment in <6 hours of symptom onset (providing a large population of early presenters), it collected prospective risk score data (to evaluate risk scores after high sensitivity troponin testing), it required physician documentation of acute coronary syndrome probability before any lab results were available, and it is the only study able to report on troponin stability in serum libraries.

INTRODUCTION

Over 10 million patients present to US emergency departments (EDs) annually with a chief complaint consistent with a suspected acute coronary syndrome (ACS).[1,2] The majority of these patients are ultimately found to be experiencing noncardiac chest pain.[3-7] Myocardial infarction (MI) is diagnosed in a minority and includes non-ST-segment elevation MI and ST-segment elevation MI. Patients who have symptoms consistent with an MI diagnosis, but without objective evidence of myocellular death, represent the disposition challenge. Those ultimately found to have a myocardial ischemic etiology for their symptoms may be termed unstable angina (UA), a condition that is often a precursor to MI. Together, the spectrum of MI and UA represents ACS.

The universal definition of MI[8] stratifies evidence of myocellular death into diagnostic categories by the dynamic changes of an elevated troponin concentration and if there is evidence of myocardial ischemia. A type I MI results from coronary artery plaque rupture. Its definition requires a rise or fall of cardiac troponin (cTn), with at least one value above the 99th percentile upper reference level (URL) obtained from a healthy population, and evidence of myocardial ischemia. Pathologically, UA may also be associated with plaque rupture, but is limited to only partial coronary artery occlusion and, by definition, has no measurable necrosis. When UA occurs, no troponin rise is detectable with contemporary assays. Since contemporary assays cannot clearly distinguish UA from noncardiac chest pain, patients with UA have historically been at risk of ED discharge, despite suffering from a high-risk ischemic event.

Advancements in assay technology have enabled lower levels of troponin detection and improved precision at low concentrations. The improved analytical performance of these assays is reflected in their definition, requiring the total imprecision (coefficient of variation) at the 99th percentile value to be ≤ 10% and measurable concentrations below the 99th percentile, but above the level of detection, attainable in at least 50% of healthy individuals.[9] None of the troponin assays described previously as 'contemporary' can achieve these benchmarks.

The importance of the improved analytic performance is supported by large studies that have demonstrated that a detectable troponin level, but below the 99th percentile of a healthy population, may be associated with unacceptable rates of short and long-term adverse cardiac events.[10,11] Regardless of the underlying etiology, and even if not associated with MI, higher troponin concentrations are a poor prognostic finding. Because high sensitivity cTn (hs-cTn) assays can detect at lower concentrations than contemporary assays, their value in prediction and exclusion of adverse events is superior. The current definition of MI that requires troponin levels to exceed the 99th percentile, can diagnose acute MI (AMI) with a contemporary troponin assay accurately but does not allow precise risk stratification of the entire population at risk for ACS.[8] Furthermore, because of the poor precision at low levels, contemporary assays cannot stratify the risk to patients until the troponin has risen significantly. This is in contradistinction to high sensitivity assays, which can give precise low concentration results, and can identify pathologic changes in troponin as early as 1 to 2 hours after symptom onset, which contemporary assays cannot.

The hs-cTn assays may add value both by revealing abnormal cTn at ED presentation that may progress to MI or by detecting an acute myocardial injury that may not progress to MI (for instance, UA). High sensitivity assays may thus enhance the clinical utility of testing for suspected ACS in the ED, and other cardiac care settings, with earlier detection that can lead to directed therapies via improved risk stratification. There is also significant potential for high sensitivity assays to enable early exclusion of MI and UA if troponin concentrations are undetectable or very low, and unlikely to rise to significant levels. This provides early

reassurance to the patient and can rationalize the use of fewer resources and facilitate an early discharge from the ED. Therefore, high sensitivity assays have the potential to enable improved patient outcomes by indicating the need for early directed investigations and therapies and reduce the health system burden of low-risk patients otherwise requiring extensive "work-up" to exclude ACS. These benefits may be present both on initial assessment in the ED and medium-term follow-up.

METHODS

Purpose

The finding acute coronary syndrome with serial troponin testing for rapid assessment of cardiac ischemic symptoms (FAST-TRAC) study was designed to determine the incremental value of a hs-cTn assay compared to a contemporary troponin assay to rule out ACS in ED patients experiencing signs and symptoms consistent with acute cardiac ischemia.

This study had two *a priori* defined primary aims: (1) to determine if hs-cTnI (cardiac troponin I) could provide improved diagnostic accuracy for ACS (including MI and/or UA) within the first 2 hours after ED presentation compared with a contemporary troponin assay. (2) To determine if hs-cTnI could provide improved prognostic information for 180-day major adverse cardiac event outcomes, compared with contemporary troponin assays.

Study population

All participating institutions obtained local ethics committee approval to participate, and all enrolled patients provided written informed consent. Inclusion criteria specified that patients were at least 18 years of age and presenting to an ED within 6 hours of symptoms consistent with ACS, defined as chest discomfort/pain, squeezing/fullness in the chest, pain radiating to left or both arms, jaw pain, pain in back/neck/stomach, shortness of breath, cold sweat, nausea/vomiting, or lightheadedness. Patients were excluded if they were in acute distress requiring immediate life-saving intervention, if they had cardiopulmonary resuscitation (defibrillation or cardioversion within 24 hours of presentation to the ED), could not provide informed consent, had a terminal illness and were not expected to survive 6 months, or had trauma likely to be the cause of their ACS symptoms (e.g., penetrating wounds).

Case report forms included baseline patient demographics, history, physical exam, ECG results, diagnostic and laboratory test results, with data handling guidelines that provide definitions and specifications on how to complete the case report form. All information recorded on the case report form was required to have verifiable source documentation.

The definition of MI used was based on cTn, with any value above the 99th percentile of the assay's reference range population defined as abnormal. The hs-TnI used for this analysis was the Access hs-TnI (Beckman Coulter, Brea, CA, USA). It has a level of detection of 2.0 pg/mL and a 99th percentile URL of 17.5 pg/mL, and sex-specific 99th percentile URLs of 19.8 and 11.6 pg/mL for males and females, respectively. For FAST-TRAC, if the hs-TnI URL was lower than the URL of the local institution's assay, all values above the hs-TnI URL but below the local assay's URL were considered "UA" on the local assay and were defined as MI when measured on the hs-TnI assay. This standard may result in the "UA" category being removed as an ACS categorization in the hs-TnI cohort.

Physicians evaluated and documented the presence of MI, UA, cardiac ischemia, and noncardiac ACS-like symptoms. At the time of the index visit, two visual analog scales were used. These defined the clinical impression of the probability of ACS and the probability of AMI and were performed by the physician who examined the patient. Another unique feature of FAST-TRAC is that the "visual analog scales at presentation" were completed within 15 minutes of the physician seeing and assessing the patient. Few studies have included such an early assessment of the clinical judgment. Additionally, the "visual analog scales after the 1st troponin" were completed after the initial local troponin result had been seen. The assessment of early clinical impression and judgment is unique and rarely reported elsewhere, it is of significant value in the evaluation of clinical assessment and the application of risk scores for disposition decisions.

After informed consent was obtained, blood draws were obtained at presentation, and 1, 2, 3 to 4, and 6 to 12 hours later. All blood draw times were ±30 minutes from the target and could occur while in the ED or after hospitalization. All draws were required for each subject, except patients who were clinically ruled out for ACS. Those discharged before 6 hours only had serial draws obtained up to the time of discharge.

The recorded outcomes included mortality, cardiac rehospitalization, cardiac events, and revascularization at 30, 90, 180, and 365 days by telephone interviews. Follow-up periods were calculated from the day of the initial event that brought the patient to the ED. Primary outcomes assessed at follow-up were defined as major adverse cardiac event and included cardiac death, revascularization (coronary artery bypass grafting, angioplasty, or stent placement), and rehospitalization due to cardiac symptoms. Secondary outcomes included all-cause death and comorbidities that have been described as potentially increasing cTnI to low abnormal levels (e.g., pulmonary embolism, heart failure, cardiomyopa-

thy, myocarditis, cardiotoxic drugs, cardiac surgery, renal failure, sepsis, and vigorous exercise) and will be analyzed for any impact on the clinical performance of the test.

Specimen handling

The FAST-TRAC study enrolled patients and collected blood samples during 2008. After collection at each site, samples were sent to the Core Laboratory (University of Maryland, Baltimore, MD, USA) for analysis using a hs-cTn assay that was not available commercially at the time of the study. Samples remained stored at –80°C until analysis. Samples were never thawed, and all troponin testing was performed in the latter half of 2020 with validated assays and run on equipment by experienced laboratory personnel at the Core Laboratory. For biomarkers investigated in FAST-TRAC, the description of the technology, sample volume, and test procedures will be described in the respective analyses. Blood was collected in a 7.5-mL heparin tube, with no separation gel. The tube was filled to at least three-quarters, centrifuged, and plasma was transferred to cryovials, then frozen and stored to at least –70°C within 1 hour of collection. Freezer temperature was monitored daily during the extended storage period and was without deviation.

"Gold standard" diagnosis guidelines

When comparing test results between two assays, a different test result must serve as the arbitrator (a test may not serve as its own gold standard). Most hs-cTn studies use the locally obtained troponin as the gold standard (and thus the contemporary troponin serves as its own gold standard). FAST-TRAC is unique in that it obtained two gold standard diagnoses (GSDs); one with and one without (and thus a solely clinical GSD) the local troponin information. These two GSDs were adjudicated independently.

Once the 30-day follow-up was complete, case report forms were reviewed by at least two board-certified cardiologists, blinded to each other's report, to provide two separate GSD, made without access to the treating physician's discharge diagnoses. In the typical case where the same two cardiologists performed both evaluations, the GSD evaluation provided two GSDs; one without the local troponin result and a second with the local troponin result. All cases were presented to the reviewing cardiologists in a separate order and > 14 days apart to minimize bias. All evaluations were reviewed for consistency by a designated Endpoints Committee. When the GSDs were not in agreement between the two reviewing cardiologists, a third cardiologist served as the tie-breaker.

GSD evaluation no. 1

This evaluation was made without discharge diagnoses from the ED or hospital and without any diagnostic information in the medical record that referred to ST-segment elevation MI, non-ST-segment elevation MI, or UA. In addition, any local troponin, creatine kinase MB fraction, or myoglobin values were blinded, as was the high sensitivity cTn result, and redacted from the case report form received by the adjudicators. This evaluation determined if the primary diagnosis for the subject was ACS. If it was not ACS, a single alternative primary diagnosis was indicated.

GSD evaluation no. 2

This evaluation used the local troponin and all information that would normally be used to assess the diagnosis (including discharge diagnoses and references to AMI and UA). Creatine kinase MB fraction and myoglobin values remained blinded.

Definitions

AMI was defined by current guidelines.[8] If the diagnosis was AMI, the type of AMI (type 1 or type 2) was then determined by definitions derived from current guidelines.

Type 1

Spontaneous MI related to ischemia due to a primary coronary event such as plaque erosion and/or rupture, fissuring, or dissection.

Type 2

MI secondary to ischemia due to either increased oxygen demand or decreased supply (e.g., coronary artery spasm or embolism, anemia, arrhythmias, etc.), with evidence of ischemia.

UA

As detailed in the reporting guidelines[12] described by the Multidisciplinary Standardized Reporting Criteria Task Force.

Other predefined primary and secondary diagnosis category

Other predefined primary and secondary diagnosis categories included "cardiovascular disease but non-ACSs" (e.g., pericarditis, myocarditis, tachyarrhythmias), "noncardiac symptoms," and "symptoms of unclassified cause." If AMI was excluded in the ED but no further diagnostic procedures were performed for a conclusive diagnosis, symptoms were defined as of unclassified origin.

Statistics

The statistical analyses will use SPSS ver. 13.0 (SPSS Inc., Chicago, IL, USA) and Analyse-it ver. 2.12 (Analyse-it Software Ltd., Leeds, UK), with significance defined as <0.05. All data will be analyzed on an intention-to-treat basis. Comparisons will be made using a t-test (analysis of variance), Fisher exact test, survival analysis (Kaplan-Meier method), and chi-square test, as appropriate. All hypothesis testing will be two-tailed. For primary endpoints 1 and 2, a comparison of receiver operating characteristic (ROC) curves for paired data will be conducted.

The sample size was calculated based on the first primary endpoint (see Purpose section above). Therefore, for ACS patients at ≤ 2 hours, if area under the ROC curve 1 = 0.85 for the hs-cTnI assay and area under the ROC curve 2 = 0.80 for a current cTnI assay, the correlation between measures is 0.80, the prevalence of ACS is 10% (extremely conservative assumption), and the power is 90%, the sample size should be at least 1,250 enrollees.

A rate of rise analysis will be used to differentiate acute from chronic heart disease and the severity of the disease. In addition, a Likert scale analysis was used to correlate *a priori* clinical diagnosis to test results.

To ensure the prognostic primary endpoint (risk stratification endpoint) was covered adequately with this sample size, detectable hazards were computed by the Shoenfeld formula.[13] Power was set to 80% with level alpha = 0.05 (two-tailed), assuming 1,250 subjects without censorship due to loss to follow-up. The predictor was assumed split at the median, giving 625 in each group. Time-to-event analysis was to be performed, the event rate was assumed at a single sentinel time point to define the primary test. However, since the actual time of the event will be known for every subject, the Kaplan-Meier curves will be shown (with a reference line at the sentinel time point). The model assumes no censoring (since death is an event). If subjects are lost to follow-up, then this rate would be incorporated into the model (increasing the hazard ratio detectable or decreasing power).

DISCUSSION

FAST-TRAC is one of the few studies where both the clinical judgment of the care team was assessed and a GSD is adjudicated without a troponin result being known. This unique strategy allows the accurate determination of diagnostic and prognostic differences between contemporary and hs-cTn assays. Furthermore, by prospectively requiring the treating physician to provide an estimate of the probability of ACS, the additive value of the physician impression can be evaluated. Additionally, because the risk score data were obtained prospectively, its utility in determining disposition decisions can be evaluated in the post-hs-cTn era. Finally, because the entry criteria required less than 6 hours of symptoms, a metric that is uncommonly evaluated in the contemporary literature, an objective measure of the utility of troponin testing in very early presentation will be determined. These unique study features will contribute significantly to the clinical applicability of hs-cTn.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Case Report

Gastric bezoar and intraoral foreign body after plaster ingestion successfully treated without surgical intervention: a case report

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Some cases of plaster ingestion include the occurrence of gastrointestinal obstruction that requires surgery. To date, there are no reports on the treatment of plaster lesions in the mouth. A 50-year-old woman was referred to the emergency department after intentionally drinking a solution of approximately 100 g of plaster powder in 250 mL of water, 3 hours earlier. On arrival, the patient was alert but unable to speak because the plaster had hardened in her mouth. Hardened plaster was also found in her stomach. There was no evidence of acute gastrointestinal obstruction on abdominal computed tomography; we therefore decided to perform surgical observation. The intraoral plaster lesions were successfully removed using forceps, and the plaster bezoar was successfully eliminated without surgical treatment. The present case shows that not all patients with plaster poisoning require surgery; the patient's conditions, such as gastrointestinal obstruction, should indicate the course of treatment.

Keywords Calcium sulfate; Eating; Treatment; Case report

Capsule Summary

What is already known

There are a few cases of gastric bezoars developing after plaster ingestion. In those reports, the plaster was surgically removed. However, no standard treatment guidelines have been established for patients with plaster ingestion. In addition, no cases of hardening of plaster in the oral cavity have been reported.

What is new in the current study

The present case shows that not all patients with plaster ingestion require surgery. To decide the appropriate treatment, the patient's condition, time from the plaster ingestion to emergency department arrival, mixing ratio of plaster powder to water, and diagnostic imaging tests should be accurately determined.

Ahn GJ, Cha YS. Gastric bezoars and intraoral foreign body developed due to plaster ingestion successfully treated without surgical intervention. Clin Exp Emerg Med 2022;9(2):146-149. https://doi.org/10.15441/ceem.20.033

INTRODUCTION

Plaster is a white powder consisting of 98% to 100% calcium sulfate hemihydrate ($CaSo_4 \cdot 1/2\ H_2O$), a substance that hardens when mixed with water. Plaster has not yet been classified as nontoxic to humans, but its lethal dose is currently unknown.[1] Acute exposure to plaster can irritate the eyes, skin, and airways, whereas plaster ingestion can cause gastrointestinal obstruction that results in nausea, vomiting, and abdominal pain.[1]

A few cases of gastric bezoars developing after plaster ingestion have been reported. In these reports, the plaster was surgically removed.[2,3] However, no standard treatment guidelines have been established for patients who ingest plaster. In addition, to the best of our knowledge, no cases of hardened plaster in the oral cavity have been reported.

Here, we report the case of a patient who arrived at the emergency department (ED) with hardened plaster in the oral cavity and stomach after ingesting a solution containing plaster.

CASE REPORT

A 50-year-old female patient was referred to the ED after intentionally drinking a solution of approximately 100 g of plaster powder in approximately 250 mL of water, 3 hours prior. She had no significant medical or surgical history, except for psychological problems that began 6 months earlier for which she had not received psychiatric treatment.

On arrival, the patient was alert but unable to speak because the plaster had hardened in her mouth. She communicated with the medical staff by writing on paper. Her chief complaints were discomfort in the epigastric area, nausea, and difficulty swallowing. The patient was hemodynamically stable, and had no specific abnormal laboratory test results, including drug screening results. On physical examination, white, hardened plaster deposits were evident in the area around her mouth and within her oral cavity (Fig. 1). In the pharynx, the white plaster had almost completely filled the lumen. In addition, in the epigastric area, a hard mass that moved in response to breathing was palpated.

We requested an emergency consultation from the otolaryngology department to confirm the airway patency. Fiberoptic examination revealed a white plaster mass in the oral cavity and oropharynx, but the upper airway, including the laryngeal area, was undisturbed (Fig. 1 and Supplementary Fig. 1). Subsequently, plain abdominal radiography was performed, which revealed a radio-opaque lesion in the upper abdomen (Fig. 2A).

Additional emergent consultations with a clinical toxicologist, dentist, otolaryngologist, and general surgeon were performed to discuss the case and decide the treatment strategy for the pa-

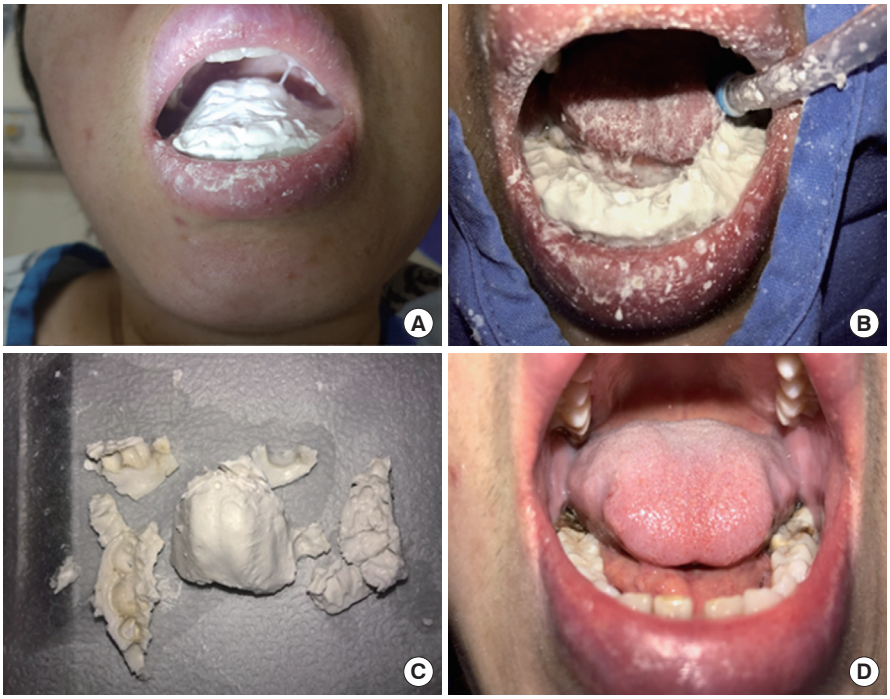

Fig. 1. White plaster material in the oral cavity and its mechanical removal using forceps. (A) Initial, (B) partial removal status in oral cavity, (C) removed plaster material, and (D) complete removal status in oral cavity. Written informed consent for publication of the clinical images was obtained from the patient.

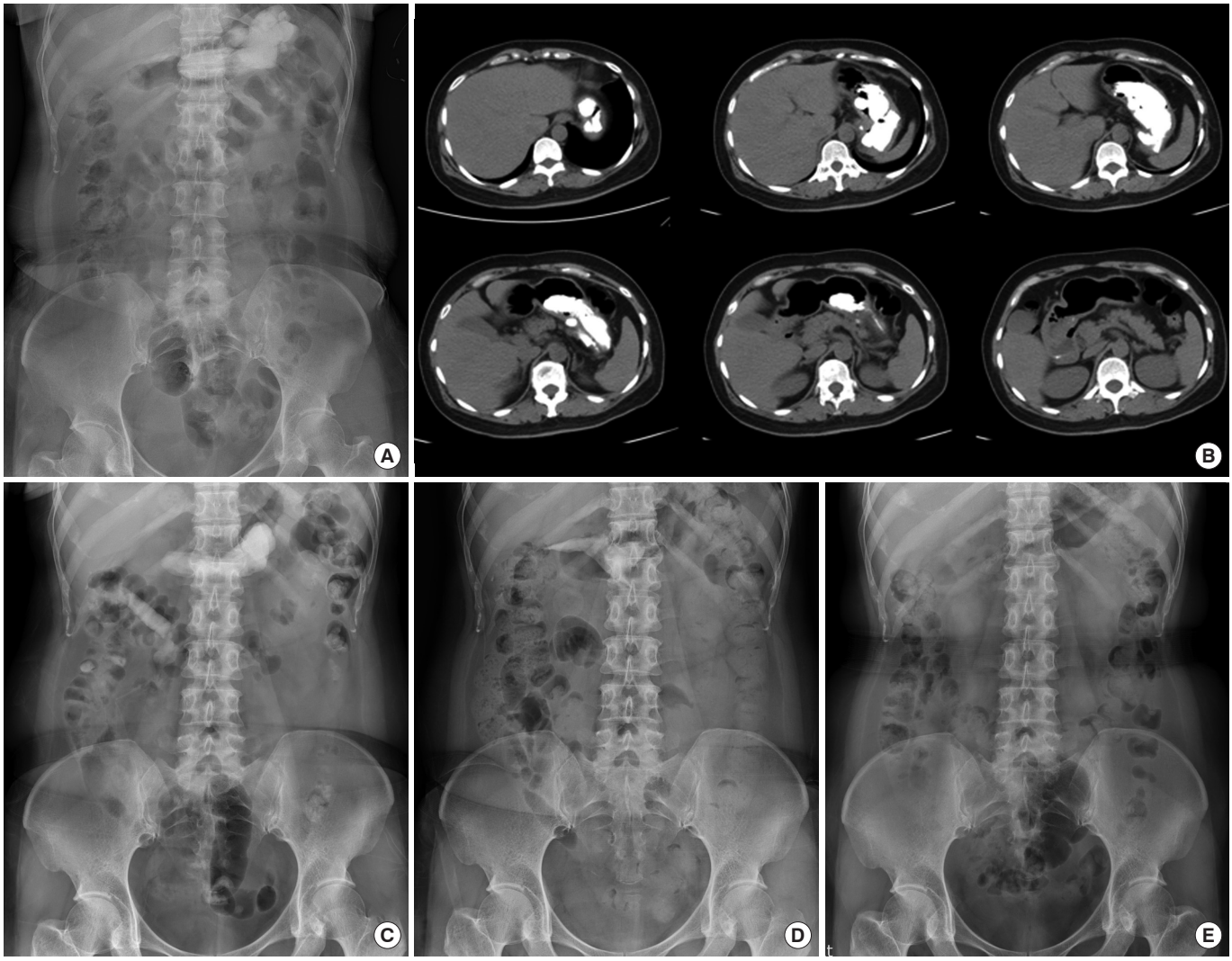

Fig. 2. Gastric cast on plain abdominal radiographs and abdominal computed tomography scan of (A, B) at the emergency department, (C) hospital day 4, (D) hospital day 7, and (E) 3 weeks after discharge.

tient. The treatment plan was as follows: first, the dentist would try to remove the intraoral plaster lesions with irrigation and forceps. If this was unsuccessful, the otolaryngologist would treat the patient surgically under general anesthesia. Next, the patient would undergo an abdominal computed tomography (CT) scan for viewing of the gastrointestinal lesions and the degree of gastrointestinal obstruction. An endoscopy would be performed if endoscope insertion could be achieved.

The abdominal CT revealed a single radiopaque foreign body inside the gastric lumen (gastroesophageal junction, fundus, and body of the stomach) which did not cause stomach distension. Endoscopy was planned to evaluate the corrosive damage of the esophagus and stomach and for endoscopic removal of plaster. Nasogastric tube insertion was attempted, but was unsuccessful owing to the plaster deposited at the gastroesophageal junction. Therefore, we thought it would be too difficult for the endoscope to enter the stomach. We planned to perform surgical observation rather than an emergency operation because the patient did not experience vomiting or severe abdominal pain and bezoars were not observed around the pylorus on CT imaging (Fig. 2B). If there were signs of gastrointestinal obstruction or no passage of the plaster during surgical observation, we would have recommended surgery.

In the ED, the dentist successfully removed the intraoral plaster with forceps (Fig. 1). The patient was then hospitalized in a general medicine ward. During hospital day (HD) 3, a follow-up abdominal radiograph was performed; the radiograph showed that the plaster content in the stomach had reduced in size. The patient was started on a liquid diet on HD 4, which was well tolerated (Fig. 2C). On HD 7, a follow-up abdominal radiograph re-

vealed that the plaster content in the stomach had further reduced in size (Fig. 2D). The patient was discharged in good condition on HD 10. She was referred to a psychiatric clinic for treatment of the underlying psychological disorder. Three weeks after discharge, the patient's abdominal radiograph showed that all the plaster in the stomach had been cleared (Fig. 2E). We analyzed the patient's serum calcium and sulfate levels serially to detect any increases due to the plaster powder content of calcium sulfate. The patient's serum calcium and sulfate levels remained unchanged. The patient provided informed consent for publication of the research details and clinical images.

DISCUSSION

In previous cases, gastric plaster bezoars caused by plaster ingestion have required surgical removal.[2,3] The case presented here is rare as the patient was treated using conservative methods, such as the use of forceps for the removal of the intraoral plaster lesions without surgical intervention and the spontaneous passage of the plaster bezoar from the stomach. There are cases reported in the literature where patients without evidence of gastrointestinal obstruction were treated with gastric lavage without surgical intervention despite the size of the obstruction being large enough to cause stomach distension.[4,5] In the present case, nasogastric tube insertion for gastric lavage was attempted but the nasogastric tube could not pass due to the plaster deposited at the gastroesophageal junction.

We propose two factors responsible for the differences observed in our patient's clinical course compared to previous cases reported in the literature. First, in our case, the patient arrived at our ED in a relatively shorter time frame following ingestion compared to the patients in other cases reported in the literature. If the patient had waited longer before visiting the ED, the intraoral plaster would have hardened further, making it impossible to remove with forceps. In addition, it would have been impossible to remove the gastric plaster contents spontaneously. The patient would have required major surgery involving a dentist, general surgeon, and thoracic surgeon. Second, the ratio of plaster powder and water consumed is essential. It is well-known that when a large amount of plaster powder in a small amount of water is ingested, the plaster is denser and hardens quickly. In such a situation, surgical treatment must be strongly considered. In our case, the patient drank approximately 100 g of plaster powder in 250 mL of water; therefore, the plaster was not as hard, and could dissolve over time and be eliminated naturally.

We tested the plaster powder, received from the patient, to visualize how it would harden if the same amount of water and plaster powder were mixed together. We have attached the experimental video as a supplemental file (Supplementary Video 1).

The present case shows that not all patients who ingest plaster require surgery. To determine the appropriate treatment, the patient's condition, time from the plaster ingestion to ED arrival, ratio of plaster powder to liquid consumed, and the size of obstruction evaluated through diagnostic imaging tests should be comprehensively considered.

SUPPLEMENTARY MATERIAL

Supplementary Fig. 1. Upper airway view of emergent fibroscopy examination

Supplementary Video 1. Movie showing tests of plaster hardening capacity

Supplementary materials are available from: https://doi.org/10.15441/ceem.20.033.

CONFLICT OF INTEREST

No potential conflicts of interest relevant to this article was reported.

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Clinical and Experimental Emergency Medicine

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Case Report

Concomitant intravascular and extravascular obstructive shock: a case report of cardiac angiosarcoma presenting with pericardial tamponade

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Atraumatic pericardial tamponade and intracardiac masses are both recognized etiologies of acute obstructive shock. Pericardial tamponade, is a cardiovascular emergency commonly considered by emergency physicians and, as a result, evaluation for this process has been incorporated into standardized point of care ultrasound algorithms for assessing hypotension. Obstructive shock secondary to intracardiac tumors is an atypical clinical presentation, and although it is evaluated by the same ultrasound imaging modality, it is generally not considered or evaluated for in the emergency department setting. The concomitant presentation of these two pathologic processes is an extremely rare oncologic emergency. Existing literature on the subject is found in a small number of case reports with nearly no prior descriptions in emergency medicine references. In the right clinical context this unique presentation should be considered and evaluated for in the emergency department via point of care ultrasound modality to help guide in the management of the resulting obstructive shock.

Keywords Shock; Resuscitation; Emergency medicine; Critical care; Case report

Capsule Summary

What is already known

Atraumatic pericardial tamponade and intracardiac masses are both recognized etiologies of acute obstructive shock. Pericardial tamponade, is a cardiovascular emergency commonly considered by emergency physicians and, as a result, evaluation for this process has been incorporated into standardized point of care ultrasound algorithms for assessing hypotension.

What is new in the current study

The concomitant presentation of intravascular and extravascular obstructive shock, secondary to both pericardial tamponade and an intracardiac tumor, is extremely rare. Existing literature on the subject is found in a small number of case reports with nearly no prior descriptions in emergency medicine references. In the right clinical context this unique presentation should be considered and evaluated for in the emergency department via point of care ultrasound modality to help guide in the management of the resulting obstructive shock.

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INTRODUCTION

Atraumatic pericardial tamponade and intracardiac masses are both recognized etiologies of acute obstructive shock. Pericardial tamponade, is a cardiovascular emergency commonly considered by emergency physicians and, as a result, evaluation for this process has been incorporated into standardized point of care ultrasound (POCUS) algorithms for assessing hypotension.[1] Obstructive shock secondary to intracardiac tumors is an extremely rare clinical presentation and, although it is evaluated by the same ultrasound imaging modality, it is rarely considered, or evaluated for, in the emergency department (ED) setting. Furthermore, due to the extremely uncommon concomitant incidence of these two pathologic processes, cardiac tamponade as the initial manifestation of an intracardiac tumor has almost no literary precedence in the emergency medicine literature despite its unique clinical features and significant clinical implications.

CASE REPORT

A 24-year-old female patient with no past medical history presented to the ED with 1 week of intermittent abdominal pain. The patient reported no fever, and prior to arrival in the ED had one episode of nonbilious and nonbloody vomiting. The patient reported no chest pain, shortness of breath, hemoptysis or any other cardiopulmonary symptomatology, as well as no dysuria or other urinary complaints.

In the ED, the patient's initial vital signs were temperature 36.8°C, blood pressure 123/86 mmHg, heart rate 124 beats/min, and oxygen saturation 100% on room air. The patient's general appearance was significant for perioral and distal upper extremity cyanosis. There were no muffled heart sounds, rubs, gallops, or murmurs on cardiac exam. Lungs were clear to auscultation bilaterally. The abdomen was soft with mild epigastric and right upper quadrant tenderness. No rebound or guarding were noted. There was no lower extremity edema. Initial laboratory studies included a normal complete blood count with no evidence of anemia, neutropenia or thrombocytopenia. Complete metabolic and hepatobiliary panels were significant for bilirubin 1.5 mg/dL, alanine aminotransferase/aspartate aminotransferase 49/43 U/L, and lactate 3.0 mmol/L. The patient was noted to have a beta Human Chorionic Gonadotropin (HCG) of 0 IU/L.

Due to the primary complaint of abdominal pain the patient was taken for computed tomography imaging which showed findings concerning for a metastatic disease process, including multiple liver lesions as well as evidence of pleural and pericardial fluid accumulation. Upon returning to the ED, approximately 6 hours of initial presentation to the ED, the patient was noted to have markedly worsening dyspnea, cyanosis and jugular venous distention. Persistent tachycardia was also appreciated with an electrocardiogram showing sinus tachycardia with low voltage (Fig. 1). Emergent evaluation with cardiac windows of the rapid ultrasound for shock and hypotension (RUSH) exam, via a phased array probe, demonstrated a large pericardial effusion. Swinging of the heart

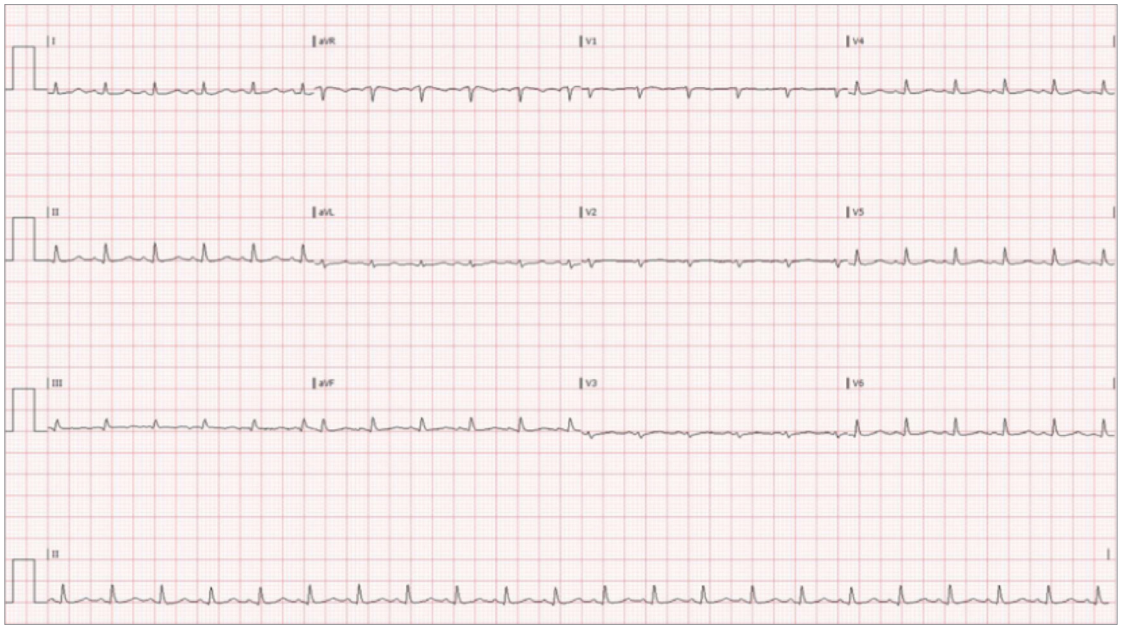

Fig. 1. Electrocardiogram prior to pericardiocentesis demonstrating both low voltage and tachycardia.

in the accumulated fluid as well as right ventricular collapse during diastole were seen on the ED POCUS exam, consistent with radiographic findings of shock secondary to tamponade. The patient subsequently developed hypotension with a blood pressure of 90/60 mmHg. Other pertinent findings in the ED included a chest X-ray consistent with the large pericardial effusion and "water-bottle" heart (Fig. 2).

The patient was admitted to the cardiac intensive care unit where additional ultrasound imaging demonstrated a large 5×5-cm space occupying mass in the posterior wall of the right atrium with extension into the superior vena cava (Fig. 3). The patient underwent an emergent pericardiocentesis with the removal of 2 L of serosanguinous fluid only partially improving the patient's shock. A drain was left in place. However, despite definitive management anticipated improvement in blood pressure was not achieved and the patient remained hypotensive. These findings were thought to be secondary to the intracardiac obstructing mass. A repeat electrocardiogram demonstrated persistently low voltage but with a marked improvement of the patient's heart rate (Fig. 4). Subsequently, the patient was transferred to another center with extracorporeal membrane oxygenation capabilities, however, this therapy was never initiated. Cytology of the pericardial fluid dem-

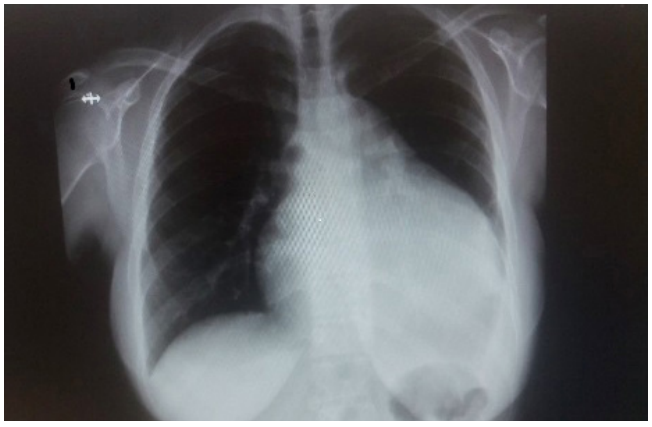

Fig. 2. Chest X-ray demonstrating "water-bottle" heart suggestive of pericardial effusion.

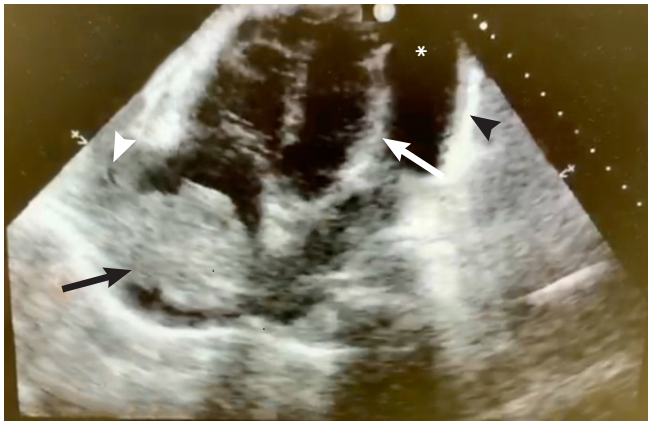

Fig. 3. The 5×5-right atrial mass (black arrow) extending into the vena cava (white arrowhead). Left ventricular wall (white arrow) and pericardial lining (black arrowhead) also associated with a large pericardial effusion (asterisk).

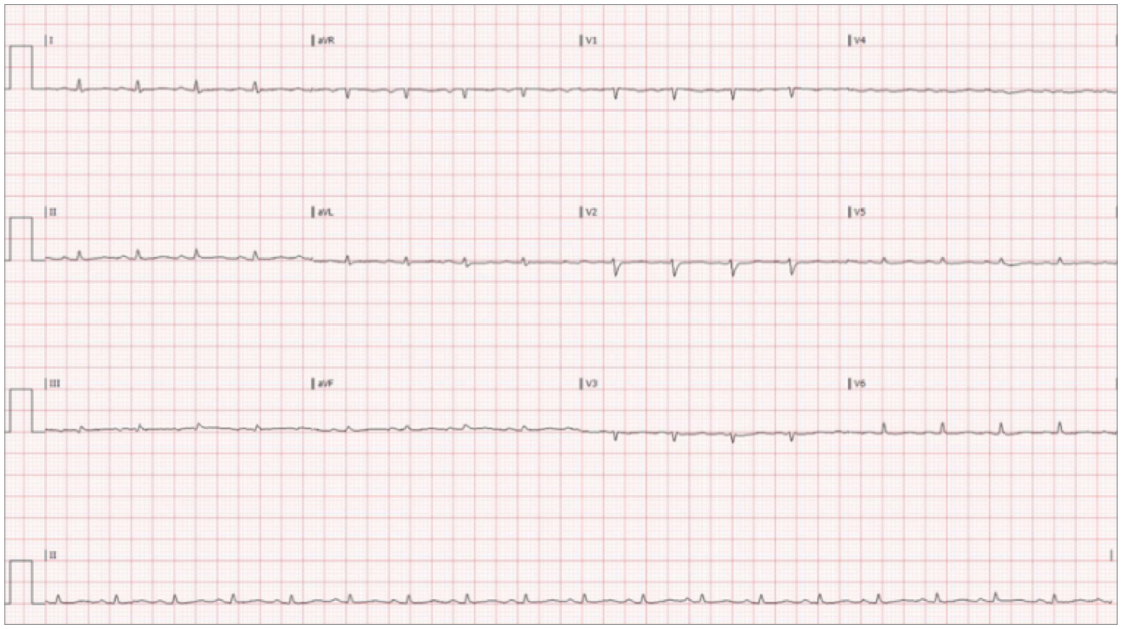

Fig. 4. Electrocardiogram following pericardiocentesis demonstrating low voltage but marked improvement of tachycardia.

onstrated that the accumulating effusion contained no malignancy. Subsequent biopsy studies of the mass were consistent with a primary cardiac angiosarcoma. The patient underwent chemotherapy followed by surgical debulking with clinical improvement. The patient provided written informed consent for publication of the research details and clinical images.

DISCUSSION

Atraumatic pericardial effusion, with and without tamponade physiology, is a pathologic process encountered by emergency physicians, reflecting a wide differential diagnosis.[2] In their most extreme physiologic manifestation large, or rapidly accumulating, effusions can lead to cardiac tamponade, extravascular obstructive shock and cardiovascular collapse. It has been reported that 11% of all pericardial effusions test positive for malignancy. However, the rate of pericardial effusions secondary to an underlying malignancy, without findings of malignant cells via cytology is not clearly established.[3] Our case, however, is consistent with the prior literature, where effusions secondary to cardiac angiosarcomas, and other primary cardiac tumors, do not demonstrate malignant cells during cytological examination.[4,5] The underlying physiologic mechanism for cardiovascular collapse is based on impaired left ventricular filling (preload) secondary to external pressure on the myocardium resulting in limited ventricular relaxation during diastole. This ultimately results in diminished cardiac output, systemic hypoperfusion and shock.[6]

The commonly accepted practice of assessing for pericardial effusions and tamponade in the ED for patients presenting with both cardiovascular symptomatology and hemodynamic instability has led to the nearly ubiquitous use of the POCUS modality with established imaging protocols in the form of the FAST (focused assessment with sonography in trauma) and RUSH examination, which both include primary cardiac views.[1] Historically, early clinical signs of acute cardiopulmonary compromise- including unexplained tachycardia, cyanosis and jugular venous distention, all features consistent with our patient's presentation- should prompt further investigation with point of care cardiac imaging. For nearly a decade the use of POCUS examinations for the assessment of cardiovascular shock, has been formally accepted in the emergency medicine community by its governing academic bodies.[7] In addition, extensive clinical research has demonstrated the efficacy of this modality when used by emergency medicine physicians.[8] Furthermore, it has been well established that most clinical findings, including diminished heart sounds which were not appreciated in our patient, have extremely poor sensitivity limiting their contributions to diagnosis and management.[9]

Primary cardiac tumors are extremely rare with a reported prevalence of 0.0001% to 0.003%.[10] Cardiac angiosarcomas commonly originate from vascular endothelial cells. They typically occur in the right atrium, are often advanced on initial presentation, and may compromise blood flow from the vena cava to the right atrium leading to an intravascular obstructive shock process with hemodynamic compromise. Specifically, cardiac masses located at the cavoatrial junction, as well as those abutting intracardiac valves, have been known to obstruct left ventricular filling and ultimately cardiac output leading to a true, but often underrecognized, oncologic emergency.[11] While POCUS ultrasonography is not currently a definitive study in assessing for intracardiac masses, abnormal findings should prompt further evaluation via comprehensive echocardiography or another imaging modality.

In contrast to pericardial tamponade, a clinical process regularly considered and evaluated within the ED, intracardiac tumors, which can be assessed via the same imaging modality, are rarely ever considered as an underlying etiology of acute shock. It is, however, well established that goal directed ultrasound protocols in nontraumatic, symptomatic hypotensive patients can improve diagnostic accuracy in the undifferentiated patient.[12] To date, there are limited existing reports dealing with presentation of cardiac angiosarcomas with associated pericardial tamponade, and virtually no prior references in the emergency medicine literature. In some instances, clinicians may overlook primary cardiac masses as the underlying cause of a pericardial effusion.[13] The limited case reports that do exist suggest that the development of pericardial effusions are possible secondary to compromise of integrity of the atrial wall.[14,15] Nearly none of the previous literature discuss the relationship between both intravascular and extravascular obstructive shock secondary to a concomitant tamponade and intracardiac obstructive physiology.

Ultimately, the copresentation of these two pathologic processes is extremely rare. Existing literature is found in a small number of case reports with nearly no prior descriptions in emergency medicine references. In the correct clinical context this unique presentation should be considered and evaluated for in the ED via POCUS modality to help guide in the management of resulting obstructive shock.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Case Report

Serratus anterior plane block as a bridge to outpatient management of severe rib fractures: a case report

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Rib fractures account for a significant number of emergency department visits each year. A patient's disposition often depends on the severity of rib fractures, comorbidities, and ability to achieve adequate analgesia. We present a 44-year-old male patient with severe pain secondary to rib fractures. The initial disposition was to admit for pain control. However, upon performing a serratus anterior plane block, patient was functionally appropriate for discharge with proper return precautions. Serratus anterior plane block is within the skillset of the emergency physician and can be used to achieve analgesia for rib fractures without the sedative and respiratory depressive effects associated with opioids.

Keywords Pain management; Emergency treatment; Nerve block; Rib fractures; Case report

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Capsule Summary

What is already known

It has been described in case reports that emergency physicians can perform the serratus anterior plane block with skill and efficacy for patients that are admitted for severe rib fractures. It is also well documented in anesthesia literature that this procedure may offer pain relief to postoperative patients who had undergone thoracic surgery.

What is new in the current study

There have been no case reports on performing this plane block in order to bridge a patient to appropriate and safe outpatient care. We have found an improvement to incentive spirometer scores and pain scores thirty minutes after administration of the plane block, as well as sustained improvement to both of these objective measures several days later on follow-up.

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INTRODUCTION

Each year an estimated 248,000 emergency department (ED) encounters and 46,000 hospital admissions occur in the United States due to a diagnosis of rib fracture.[1] Despite an estimated 12.9% decrease in overall traumatic injury rate in the ED, the rate of rib fractures has increased by 19%.[1] Approximately 13% of patients with at least one rib fracture experience complications which may include pneumonia, acute respiratory distress syndrome, pulmonary embolism, or empyema.[2] Advanced age and a total number of rib fractures are independent risk factors for increasing the complication rate.[3]

A principal goal in managing rib fractures, the pain of which often impedes deep inspiration, is to provide analgesia without further contributing to atelectasis by depressing respiration or increasing airway obstruction.[4] Although opioids can act as effective analgesics, they also suppress ventilatory drive and can cause excess sedation, which is counterproductive in the context of treating rib fractures.[5] Agents such as nonsteroidal anti-inflammatory drugs and ketamine have been found to decrease opioid requirement in patients with rib fractures,[6,7] but are short-acting and contraindicated in certain patient populations. Thoracic epidurals are a common interventional technique to treat rib fracture pain. However, a recent matched analysis of 1,360 patients found no mortality benefit and significantly higher rates of respiratory complications such as pneumonia, respiratory failure, and pulmonary embolism.[8] Furthermore, epidurals are largely out of an emergency physician's scope of practice, and recommending one requires inpatient hospital admission for epidural placement and management, which may not be the ideal disposition for an otherwise healthy patient presenting with rib fractures.

Recently, there have been a number of studies described in the anesthesia literature describing the efficacy of ultrasound guided serratus anterior plane blocks (SAPBs) prior to thoracoscopic surgery.[9,10] The plane between the serratus anterior and latissimus dorsi muscles houses the intercostobrachialis nerve, lateral cutaneous branches of the intercostal nerves, long thoracic nerve, and thoracodorsal nerve.[11] The goal of local anesthetic administration into this plane is to provide analgesia across a unilateral T3-T9 dermatomal distribution.

CASE REPORT

A 44-year-old previously healthy male patient presents to the ED with 5 days of severe, right sided chest wall pain. He stated that approximately 5 days ago, he was involved in a motorcycle accident, and sustained multiple right sided rib fractures and was hospitalized at an outside hospital and discharged yesterday. He then came to our ED with worsening chest wall pain that was exacerbated with deep breaths. He had difficulty ambulating and repositioning in bed secondary to his chest wall pain. He had tried taking oxycodone-acetaminophen 5 to 325 mg at an unknown frequency at home without relief.

When asked about his hospital course and follow up plan, he stated that he could not recall due to a significant number of medications administered for pain that caused drowsiness during his entire hospitalization. The patient was unsure if he had surgery performed and could not recall the exact number of days he was hospitalized.

On examination, he was tachypneic to 27 breaths/min and saturating 94% on room air. The rest of his vital signs were within normal limits. The patient was in severe pain especially upon repositioning. Physical exam was notable for tachypnea, shallow breaths, and decreased breath sounds bilaterally, without any wheezes, rales or rhonchi. Significant ecchymosis was noted to his right superior axilla, his right flank, and right buttock. Two lateral incisions on his right chest wall were noted to be well-approximated without signs of infection or surrounding crepitus. However, the patient was exquisitely tender to palpation in this distribution. An eFAST (extended focused assessment with sonography for trauma) was performed and was negative for any acute findings.

A chest X-ray was performed which revealed low lung volumes bilaterally, left greater than right bibasilar atelectasis, right lateral chest wall subcutaneous emphysema, and right sided rib fixation

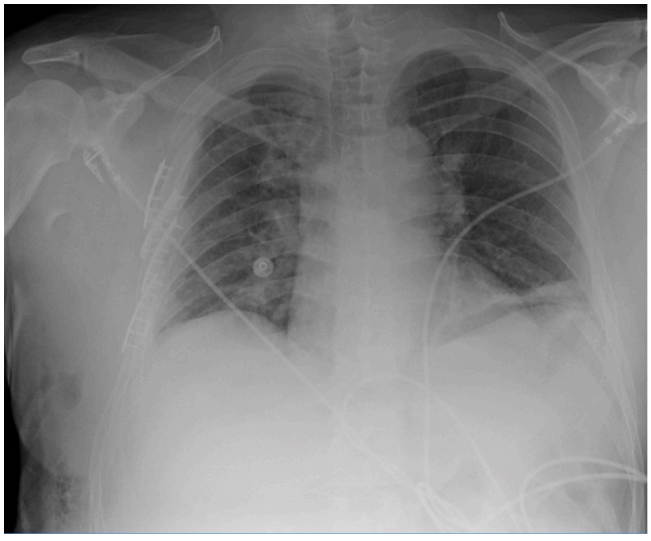

Fig. 1. Anterior-posterior chest X-ray depicting lung volumes bilaterally with bibasilar atelectasis. Also noted is right lateral chest wall subcutaneous emphysema and right sided rib fixation hardware.

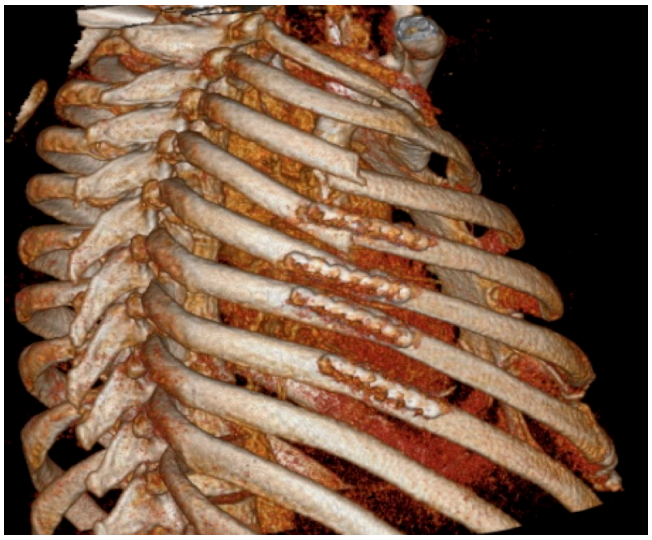

Fig. 2. A three-dimensional reconstruction from a computed tomography angiography of the chest demonstrating eight rib fractures and rib fixation hardware.

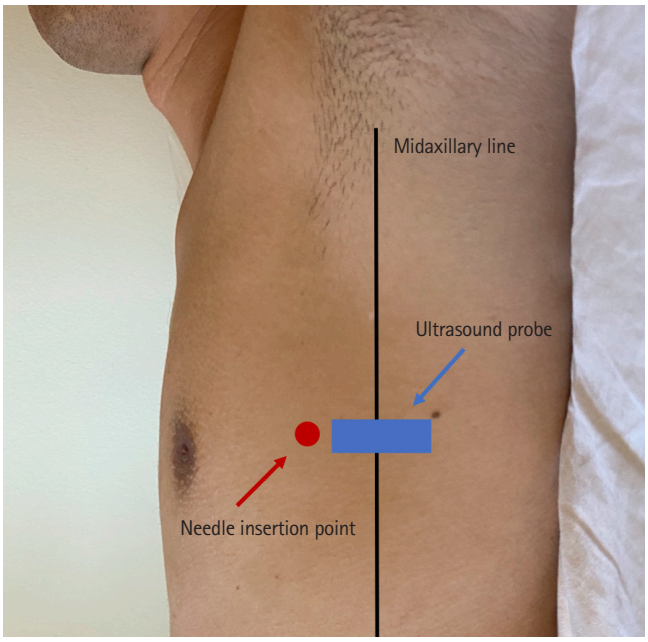

Fig. 3. Model demonstration with a supine model. Ultrasound probe to be placed (blue) in the transverse orientation at the midaxillary line and the level of the fourth or fifth rib. Needle insertion (red) at the anterior axillary line. Written informed consent for publication of the clinical images was obtained from the patient.

hardware (Fig. 1). A three-dimensional reconstruction from a computed tomography angiography of the chest was performed (Fig. 2) given the patient had a number of risk factors and symptoms concerning for pulmonary embolism such as his pleuritic chest pain, his recent trauma, recent surgery, and decreased ambulatory status.

The computed tomography angiography chest was negative for pulmonary embolism, however showed mild bibasilar dependent atelectasis and trace pneumothorax on the right side. These imaging studies demonstrated a total of eight rib fractures including the lateral third rib, the anterior and posterior third through sixth ribs, the posterior seventh rib, and the lateral eighth rib. The patient also had rib plating hardware noted on the lateral right fourth through seventh ribs. Furthermore, the patient also had a nondisplaced fracture of the inferior right scapula.

The patient initially received two separate doses of 4 mg intravenous (IV) morphine with little to no relief to his pain. His incentive spirometry was measured at 1,200 cc with significant pain. At the time, he was not amenable to discharge as his pain had not been relieved with oral medications at home, and now IV medications in the ED. The patient was offered and consented for a SAPB. The block was performed using sterile technique and under ultrasound guidance using a high-frequency linear transducer. Twenty minutes after the procedure, the patient noted a significant improvement in his pain level, and was now able to perform 1,500 cc at best effort in incentive spirometry, as compared to 1,200 cc prior to his plane block. At this time, the patient was agreeable to discharge, and was given instruction on multimodal pain therapy and prescribed lidocaine 5% patches, methocarbamol, and hydrocodone-acetaminophen 5 to 325 mg tablets for break through pain. The patient was also instructed to take ibuprofen and acetaminophen scheduled, and to continue with IS every hour while awake at home.

After 2 days, the patient was contacted for a follow-up. He reported that his SAPB relief lasted roughly 24 to 36 hours. He was then able to take additional doses of his oral pain medications. His incentive spirometry score was improved to 2,000 cc, a significant improvement from 1,200 cc at presentation to our ED. The patient was able to recall all of the events during his ED visit, along with the discharge plan that was previously discussed with him. He was significantly less sedated, able to increase his activity level, and was optimistic regarding his recovery. The patient provided written informed consent for publication of the research details and clinical images.

DISCUSSION

To perform this technique you will require an ultrasound with a high frequency linear transducer, 20 to 30 cc of bupivacaine 0.25% (maximum 2 mg/kg), 5 to 10 cc of 1% lidocaine without epinephrine, 20- to 22-gauge spinal needle, extension IV tubing, 3-way stopcock, 27-gauge needle, 30-cc syringe, 5- to 10-cc syringe,

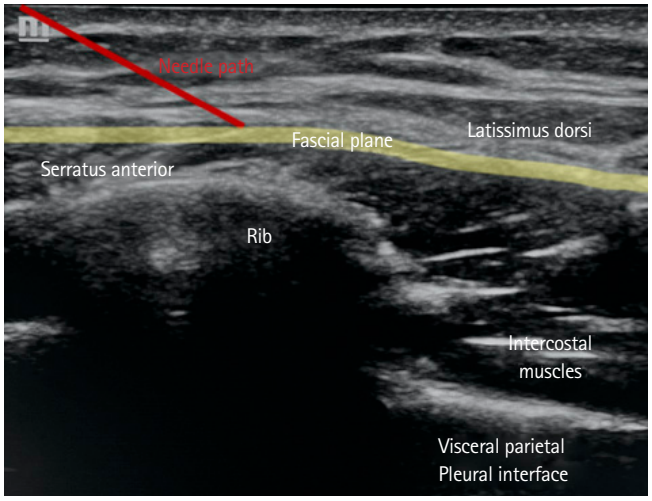

Fig. 4. Ultrasound images in the transverse view at the midaxillary line. The target is the fascial plane (yellow) in between the latissimus dorsi muscle and serratus anterior muscle. Needle path (red) should be at a 30° to 60° angle from the skin. For orientation purposes the intercostal muscles, rib, and visceral parietal pleural interfaces have been noted in the figure.

and a normal saline flush. The ultrasound probe will be placed on the patient in the transverse orientation at the midaxillary line as seen in Fig. 3. Relevant anatomy should be identified as seen in Fig. 4, with the target of injection being the fascial plane superior to the serratus anterior muscle. Once the anatomy is identified, patient should be marked, and cleansed with antiseptic cleaning solution.

Using a 27-gauge needle and 5- to 10-cc syringe, make a skin wheal at the needle insertion site and then under ultrasound guidance, infiltrate local anesthetic along the anticipated tract in which you will insert your spinal needle. Once complete, attach your spinal needle to the IV extension tubing, and then to a 3-way stopcock to the opposite end. On the other two ends of the 3-way stopcock, attach your 30-cc syringe filled with bupivacaine and your normal saline flush. Insert your spinal needle at your skin wheal at a 30° to 60° angle. In the longitudinal view under ultrasound guidance, advance your needle until you approach the fascial plane just superior to the serratus anterior muscle. The entire needle, and most importantly the tip of the needle, should be visualized with ultrasound prior to any needle advancement to best avoid pleural puncture. Once at the appropriate location, as indicated in yellow in Fig. 4, and after negative aspiration, inject 1 to 2 cc of normal saline until you visualize the appropriate separation of fascial planes. If you do not witness the spread of fascial planes, readjust your needle and once again inject with normal saline to confirm your location. Once confirmed, inject your bupivacaine solution and then flush the extension tubing with your normal saline.

In this case report, one factor that may have led to the patient's lack of pain control in the outpatient setting was his inability to recall not only the events of his hospitalization but also his discharge instructions. Although it is unclear what medications he received at the outside hospital, opioid analgesics can commonly result in over sedation and may have contributed to this patient's confusion with discharge instructions. Parenteral opioids can result in successful analgesia, however they can also contribute to excess sedation and are short-acting. The SAPB allows providers to offer patients longer lasting analgesia upon discharge without excess sedation.

Prior to performing the SAPB, the patient had received two doses of morphine 4 mg IV in our ED with little to no relief. There was concern that the patient might require admission for pain control, however given there was pain relief and improvement in his incentive spirometry volumes after the SAPB, patient and ED team agreed he was appropriate for discharge home with appropriate return precautions. His improved functional status on follow-up phone call added further credence to incorporation of SAPB as a bridging strategy for patients from the ED to the outpatient setting when combined with multimodal oral analgesics. Further studies in the form of randomized controlled trials may be warranted to determine if there is a significant reduction in pulmonary complications and opioid use after a SAPB performed in the ED for traumatic rib fractures.

This case study illustrates the feasibility of SAPB as an analgesic strategy for rib fracture pain in the ED. Although training in procedure performance may not be standard across residency programs, the Accreditation Council for Graduate Medical Education has included use of ultrasound for procedural guidance as one of the core milestones of the emergency medicine resident.[12] With a strong base in procedural skills using ultrasound guidance for common ED procedures such as central line placement, paracentesis, and diagnostic testing, it is arguably within the skill set of the emergency physician to perform the SAPB.

In our case report, SAPB provided this patient with analgesia that was less sedating and longer acting than a single administration of opioid analgesic. We believe the SAPB may be a reasonable intervention by which the emergency physician may bridge a patient to outpatient pain management of rib fractures when combined with multimodal therapy. Further studies in the form of randomized controlled studies may help to determine important benefits or consequences of this technique such as the rate of complications, rate of admission versus discharge, and overall effectiveness of pain control after SABP performed in the ED setting.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Images in Emergency Medicine

Calcific tendinitis of rectus femoris

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A previously healthy 54-year-old female patient presented with acute onset difficulty walking. She reported gradually worsening, severe pain in the right groin that was aggravated with hip flexion. She denied any recent injury or excessive loading. Physical examination revealed localized tenderness at the right anterior inferior iliac spine and a painful snapping hip. Blood examination revealed mildly elevated C-reactive protein (0.94 mg/dL; normal, <0.30 mg/dL). Radiography showed calcifications near the right anterior inferior iliac spine (Fig. 1). Computed tomography showed calcific deposits within the direct head of the right rectus femoris, which corresponded to the location of pain (Fig. 2). This confirmed the diagnosis of calcific tendinitis of the rectus femoris.

Calcific tendinitis can involve either the direct or indirect head of the rectus femoris. Direct head tendinitis is rare and presents with a gradual onset of a painful snapping hip, while indirect head tendinitis causes acute restriction of joint movement.[1] Thus, emergency physicians need to know that, although rare, calcific tendinitis of the rectus femoris can be one of the etiologies of sudden-onset difficulty walking. Calcific tendinitis of the rectus femoris can be self-limiting, but nonsteroidal anti-inflammatory drugs provide quick symptomatic relief.[1-3] Aspiration, lavage, and local corticosteroids or anesthetics may be needed in refractory cases.[1-3] For this patient, the symptoms completely resolved within two days of loxoprofen administration. Written informed consent for publication of the research details and clinical images was obtained from the patient.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

Capsule Summary

What is already known

Calcific tendinitis of the rectus femoris can present with gradual onset of painful snapping (direct head tendinitis) or restricted joint movement (indirect head tendinitis).

What is new in the current study

This case shows that calcific tendinitis of the rectus femoris can be one of the causes of acute onset of difficulty walking, and that calcifications near the anterior inferior iliac spine on radiography can provide a clue to the diagnosis.

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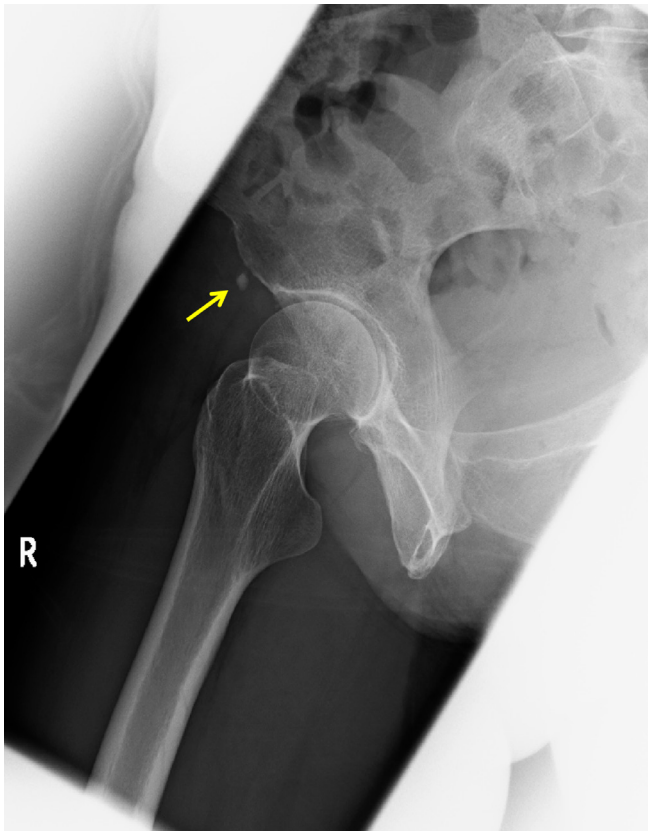

Fig. 1. Radiography revealed calcifications near the right anterior inferior iliac spine (arrow).

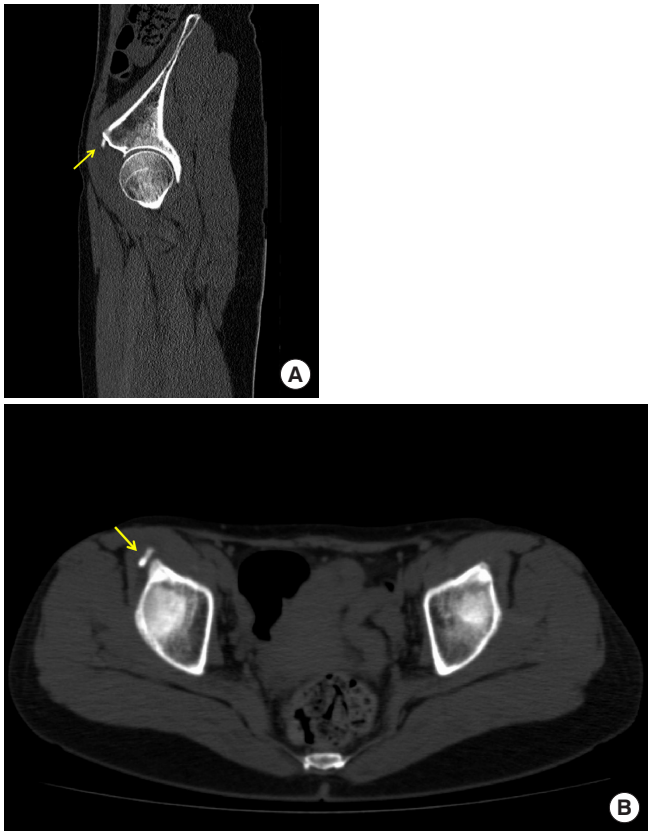

Fig. 2. Computed tomography showed calcific deposits within the direct head of the right rectus femoris (arrows) on (A) sagittal and (B) axial view.

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Erratum

Erratum to "2020 Korean Guidelines for Cardiopulmonary Resuscitation. Part 4. Adult advanced life support"

Jaehoon Oh[1], Kyoung-Chul Cha[2], Jong-Hwan Lee[3], Seungmin Park[4], Dong-Hyeok Kim[5], Byung Kook Lee[6], Jung Soo Park[7], Woo Jin Jung[2], Dong Keon Lee[4], Young Il Roh[2], Tae Youn Kim[2], Sung Phil Chung[8], Young-Min Kim[9], June Dong Park[9], Han-Suk Kim[10], Mi Jin Lee[11], Sang-Hoon Na[12], Gyu Chong Cho[13], Ai-Rhan Ellen Kim[14], Sung Oh Hwang[2]; on behalf of the Steering Committee of the 2020 Korean Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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In the article entitled "2020 Korean Guidelines for Cardiopulmonary Resuscitation. Part 4. Adult advanced life support,"[1] the affiliation for the ninth author, Dong Keon Lee, was incorrectly listed as "[3]Department of Anesthesiology and Pain Medicine, Sungkyunkwan University College of Medicine, Seoul, Korea." It has been changed to "[4]Department of Emergency Medicine, Seoul National University College of Medicine, Seoul, Korea."

Before correction

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After correction

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CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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