ORIGINAL ARTICLE

# Outcome of chest re-exploration for haemostasis in intensive care unit post-cardiac surgery: A retrospective analysis

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## ABSTRACT

**Introduction: Chest re-exploration is potentially life-saving in the treatment of early post-operative complications of open-heart surgery such as for surgical haemostasis, hemodynamic instability, and cardiac arrest. The procedure is often performed in the intensive care unit (ICU) rather than in the operating theatre (OT). The incidence of chest re-exploration may range from 2 to 12%. To analyse the complications of patients who underwent chest re-exploration in the ICU for haemostasis after heart surgery vs in those who were operated in an OT. Secondary outcome measured is all-cause mortality in the patients involved.**

**Materials and Methods: This is a retrospective analysis of patients' medical records who underwent chest re-exploration in the ICU for haemostasis over a 2-year period (2019 to 2020). The cases which needed re-exploration for haemostasis were divided into two groups: cases conducted in those ICU and those conducted in the OT. Complications post-chest re-exploration were measured and categorized into renal failure needing dialysis, pulmonary complication, gastrointestinal complication, heart failure, pericardial effusion, fever, and surgical site infection.**

**Results: 4406 cases of open-heart surgeries were analysed. 351 of the patients underwent chest re-exploration, and majority of the cases were re-explored for haemostasis (88.9%). 64.2% of the chest re-exploration were conducted in the ICU. 21.9% patients who underwent post-chest re-exploration in the ICU died, while 13.1% of the patients died post- chest re-exploration in the OT. From the total number of cases of chest re-exploration, 75.9% of patients who had chest re-exploration in the ICU developed complication, whereas patients who developed complication post-chest re-exploration in the OT were 35.1% (p-value < 0.001).**

**Conclusion: Chest re-exploration in the ICU for post-cardiac-surgery patients showed a higher percentage of complications, which contributes to mortality.**

**KEYWORDS:**
*Chest Re-exploration, Haemostasis, Post-cardiac Surgery, Intensive Care Unit, Operation Theatre*

## INTRODUCTION

Chest re-exploration is potentially life-saving in the treatment of early post-operative complications of open-heart surgery, for example, surgical haemostasis, hemodynamic instability, and cardiac arrest.[1] The overall incidence of re-exploration for bleeding ranges from 2.3 to 6%.[2-6] Bleeding post-cardiac surgery increases the rate of re-exploration, length of hospital stay, requirement of blood transfusion, and its cost.[7] The procedure is often performed in the intensive care unit (ICU) rather than the operating theatre (OT), which allows a more immediate re-exploration to be conducted. However, comparative to the OT, an ICU does not provide an environment which is as sterile, conferring greater mortality and morbidity.

The data in the literature on chest re-exploration for resuscitation is limited, as compared to the number of chest re-exploration for haemostasis. Therefore, the aim of this study is to analyse the outcome of patients who underwent chest re-exploration in the ICU vs those who underwent the procedure in an OT for haemostasis after heart surgery, and to look at the patients' all-cause mortality, post re-exploration.

## MATERIALS AND METHODS

This is a retrospective analysis of patients' medical records who underwent chest re-exploration in the ICU for haemostasis over a 2-year period (2019 to 2020) in the Department of Cardiothoracic Surgery, National Heart Institute. The study included first-time chest re-exploration for routine cases of coronary surgeries, valve procedures, and aortic surgeries. The cases which needed re-exploration for haemostasis were divided into 2 groups: cases conducted in the ICU and in the OT. The demographic data of patients, indication for re-exploration, timing and findings of the re-exploration, and the clinical outcome were analysed and recorded using Mann–Whitney U test. The exclusion criteria for this study involved patients aged <18 years, immunocompromised, and those who underwent ventricular assist device implantation surgeries and/or paediatric surgeries, chest re-exploration for deep sternal wound infection, and those who needed chest re-exploration for cardiac arrest and resuscitation. All decisions for chest re-exploration were made by the cardiothoracic consultant surgeon who performed the primary heart surgery.

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**Table I: Demographic and clinical data of the subjects recruited for this study based on the location where chest re-exploration was performed**

| Variables | ICU, N (%) | OT, N (%) | All, N (%) | p-value |
|---|---|---|---|---|
| Total No. of Cases | 192 (100) | 107 (100) | 299 (100) | |
| Gender | | | | |
| Female | 47 (24.5) | 17 (15.9) | 64 (21.4) | 0.083 |
| Male | 145 (75.5) | 90 (84.1) | 235 (78.6) | |
| Age | | | | |
| Mean ± SD | 60.7 ± 11.5 | 60.8 ± 10.5 | 60.72 ± 11.12 | 0.696 |
| Median (Min, Max) | 62.4 (22.3,80.4) | 61.7 (21.1,85.4) | 62.2 (21.1,85.4) | |
| BMI | | | | |
| Mean ± SD | 26.1 ± 4.9 | 26.1 ± 4.1 | 26.12 ± 4.63 | 0.752 |
| Median (Min, Max) | 25.4 (16.0,43.0) | 25.1 (19.0,36.6) | 25.4 (16.0,43.0) | |
| Angina Status | | | | |
| CSS (NO SIGN) | 60 (31.4) | 38 (35.5) | 98 (32.9) | 0.418 |
| CSS1 | 72 (37.7) | 47 (43.9) | 119 (39.9) | |
| CSS2 | 42 (22.0) | 16 (15.0) | 58 (19.5) | |
| CSS3 | 13 (6.8) | 4 (3.7) | 17 (5.7) | |
| CSS4 | 4 (2.1) | 2 (1.9) | 6 (2.0) | |
| NYHA | | | | |
| NYHA I | 70 (36.6%) | 46 (43.0%) | 116 (38.9%) | 0.124 |
| NYHA II | 94 (49.2%) | 55 (51.4%) | 149 (50.0%) | |
| NYHA III | 24 (12.6%) | 6 (5.6%) | 30 (10.1%) | |
| NYHA IV | 3 (1.6%) | 0 (0.0%) | 3 (1.0%) | |
| Diabetes | | | | |
| No | 87 (45.8%) | 46 (43.0%) | 133 (44.8%) | 0.641 |
| Yes | 103 (54.2%) | 61 (57.0%) | 164 (55.2%) | |
| Hypertension | | | | |
| No | 36 (18.8%) | 19 (17.8%) | 55 (18.5%) | 0.816 |
| Yes | 155 (81.2%) | 88 (82.2%) | 243 (81.5%) | |
| Hyperchlolesterolemia | | | | |
| No | 46 (24.5%) | 18 (17.1%) | 64 (21.8%) | 0.146 |
| Yes | 142 (75.5%) | 87 (82.9%) | 229 (78.2%) | |
| Renal Disease | | | | |
| No | 100 (57.5%) | 56 (56.6%) | 156 (57.1%) | 0.884 |
| Yes | 74 (42.5%) | 43 (43.4%) | 117 (42.9%) | |
| Urgency | | | | |
| Elective | 128 (68.1%) | 87 (81.3%) | 215 (72.9%) | 0.048 |
| Urgent | 53 (28.2%) | 18 (16.8%) | 71 (24.1%) | |
| Emergency | 7 (3.7%) | 2 (1.9%) | 9 (3.1%) | |

Chest re-exploration for all patients in the department was practiced in a routinely manner, except that the patient remains in the ICU bed and attached to all the necessary monitoring equipment, instead of being transferred to the surgical table. Our ICU is divided into cubicles of 2 to 4 beds, with curtains to isolate individual bed spaces. All cubicles are separated from one another via a sliding door. Each re-exploration team was led by a consultant surgeon or a senior registrar, assisted by a medical officer or a surgical assistant, along with OT nursing personnel trained in basic theatre techniques, all of whom were scrubbed.

The procedure was conducted under general anaesthesia, performed by the anaesthetist on-call. The patient was draped via the usual manner using povidone and sterile drapes. Post-incision, soft tissue and sternal edges were inspected for any bleeding points. Clots which are present in the chest cavity were evacuated and all operative sites were inspected systematically for any active bleeding. Any detected bleeding points were secured via stainless-steel clips, sutures, diathermy, or adequate application of thrombostatic material, for example, Surgicel. For cases in which haemostasis was secured, the chest cavity was cleaned and the drainage tubes were cleared for any clotted blood, prior to sternal wiring via stainless steel wires. Post-sternal wiring, the sternum was again inspected for any bleeding. Subcutaneous tissue and skin were closed with absorbable suture material. The cases in which haemostasis was uncontrollable surgically, the open chest was packed with adequate number of swaps. The chest cavity was then covered with a piece of sterile latex. Stat dose of antibiotics such as vancomycin was also commenced post-chest re-exploration.

During re-exploration, traffic is restricted only at the patient's bed space. The criteria used in deciding for chest re-exploration vary, depending on the clinical judgement of the senior registrar on-call in managing these patients. The decision for chest re-exploration will be based on the combination of a number of aspects, namely the patient's general condition as a whole, the amount of chest tube drainage per hour, the patient's input–output balance, urine output, central venous and blood pressure trend, and the haemoglobin level.

## RESULTS

Between January 2019 and December 2020, 4406 cases of open-heart surgeries were performed. Around 351 of the patients (7.97%) underwent chest re-exploration, where a majority of the cases were re-explored for haemostasis

**Table II: Types of Surgery Involved & Operative Characteristics of Patients Underwent Chest Re-exploration for Haemostasis in 2019–2020**

| Location | ICU, N (%) | OT, N (%) | All, N (%) | p-value |
|---|---|---|---|---|
| Total No. of Cases | 192 (100) | 107 (100) | 299 (100) | |
| Type of Surgery | | | | |
| CABG | 122 (63.5) | 79 (73.8) | 201 (67.2) | |
| CABG + Valve | 24 (12.5) | 11 (10.3) | 35 (11.7) | |
| Valve | 31 (16.1) | 10 (9.3) | 41 (13.7) | |
| Aortic | 8 (4.2) | 0 (0) | 8 (2.7) | |
| Others | 7 (3.6) | 0 (0) | 7 (2.3) | |
| Cardiopulmonary Support | | | | |
| On Pump | 191 (99.5%) | 107 (100.0%) | 298 (99.7%) | 0.455 |
| Off Pump | 1 (0.5%) | 0 (0.0%) | 1 (0.3%) | |
| Bypass time (Min) | | | | |
| Mean ± SD | 129.3 ± 64.9 | 113.8 ± 47.8 | 123.7 ± 59.7 | 0.128 |
| Median (Min, Max) | 110.5 (36.0,332.0) | 105.0 (44.0,273.0) | 109.0 (36.0, 332.0) | |
| Cross clamp time (Min) | | | | |
| Mean ± SD | 97.2 ± 51.0 | 87.3 ± 40.6 | 93.54 ± 47.65 | 0.182 |
| Median (Min, Max) | 84.0 (23.0,274.0) | 78.0 (33.0,237.0) | 82.0 (23.0, 274.0) | |
| Post-op Stay (Day) | | | | |
| Mean ± SD | 18.7 ± 21.3 | 16.0 ± 20.8 | 17.76 ± 21.15 | 0.159 |
| Median (Min, Max) | 12.0 (1.0 ,162.0) | 9.0 (2.0, 160.0) | 11.0 (1.0, 162.0) | |
| Outcome | | | | |
| Alive | 150 (78.1%) | 93 (86.9%) | 243 (81.3%) | 0.062 |
| Death | 42 (21.9%) | 14 (13.1%) | 56 (18.7%) | |
| Complication | | | | |
| Renal failure need dialysis | 53 (27.9%) | 20 (20.2%) | 73 (25.3%) | 0.153 |
| Pulmonary complication | 37 (19.7%) | 14 (14.1%) | 51 (17.8%) | 0.243 |
| GI Complication | 15 (8.2%) | 7 (6.7%) | 22 (7.6%) | 0.663 |
| Heart Failure | 13 (6.9%) | 5 (4.7%) | 18 (6.1%) | 0.450 |
| Pericardial Effusion | 69 (35.9%) | 32 (30.2%) | 101 (33.9%) | 0.316 |
| Fever | 29 (15.3%) | 17 (15.9%) | 46 (15.5%) | 0.886 |
| Surgical Site Infection | | | | |
| No | 176 (94.1%) | 94 (90.4%) | 270 (92.8%) | 0.238 |
| Yes | 11 (5.9%) | 10 (9.6%) | 21 (7.2%) | |

(88.9%) in the National Heart Institute. 64.2% of the total number of cases of chest re-exploration were conducted in an ICU. A higher percentage of patients who underwent post-chest re-exploration in the ICU were deceased (21.9%), compared to those in the OT group (13.1%), having a *p*-value of 0.062.

As shown below are also the demographic characteristics for the patients involved. For both ICU and OT groups, all chest re-exploration cases consist of more male than female population, with the mean age of 60 years and a mean BMI of 25. Majority of the re-exploration cases for both groups mainly consist of patients who were diagnosed as having hypertension (81.5%), diabetes mellitus (55.2%), and/or dyslipidemia (78.2%). Most cases involving chest re-exploration for haemostasis were the ones admitted for elective surgery (72.9%; *p*-value, 0.048), followed by urgent cases (24.1% and emergency cases being the least involved, with the *p*-value of 0.048).

Based on Table II, the cases were categorized into 5 types: isolated coronary artery bypass grafting (CABG) surgery, CABG and valve surgery, isolated valve surgery, isolated aortic surgery, and others, for example, excision of thoracic tumour, which does not contribute significantly in this study. Out of 299 cases of chest re-exploration for haemostasis, 67.2% were CABG cases, followed by valve cases (13.6%), combined CABG and valve cases (11.7%), and others. Patient who underwent CABG were listed as the majority group to be re-explored in both an ICU and an OT. The operative characteristics of patients who underwent chest re-exploration for haemostasis in 2019 to 2020 were shown. The least percentage of mortality involved were patients who underwent chest re-exploration in an OT (13.1%). Complications of post-chest re-exploration for haemostasis were divided into 7 categories: renal failure needing dialysis, pulmonary complication, gastrointestinal (GI) complication, heart failure, pericardial effusion, fever, and surgical site infection. Patients in the ICU group showed higher percentage of having complications post-chest re-exploration for haemostasis as compared to those in the OT group. Most of the patients did not experience surgical site infection in both the groups (92.8%).

For the patients who were deceased post-chest re-exploration, the sources of bleeding/tamponade were identified as follows: pericardial effusion, bleeding from the internal mammary arterial bed, sternal bleed, bleeding from the graft, generalized bleeding, and others. Based on Figure 1, both the ICU and the OT groups showed pericardial effusion with most common source of chest re-exploration (ICU, 49%; OT, 29%). There was no mortality caused by bleeding from the internal mammary arterial bed in either group. The types of primary surgery done for those who needed chest re-exploration for haemostasis in an ICU, relating to the patient's status were shown here. The number of deceased patients' post-chest re-

**Table III: Logistic regression analysis of factors predicting mortality caused by chest re-exploration**

| Univariable Predictors of Mortality<br>Dependent variable: Mortality<br>Variable | Univariate Analysis | | | | p-value |
|---|---|---|---|---|---|
| | Beta | Odd Ratio (OR) | 95% Confidence Interval for Difference | | |
| | | | Lower Bound | Upper Bound | |
| Gender; Female = 1 as references | -0.598 | 0.550 | 0.286 | 1.056 | 0.073 |
| Age (Year) | 0.051 | 1.052 | 1.018 | 1.087 | 0.002 |
| BMI | -0.015 | 0.985 | 0.914 | 1.061 | 0.688 |
| Angina Status; CSS (NO SIGN) = 1 as references | | | | | |
| CSS1 | -0.091 | 0.913 | 0.439 | 1.902 | 0.809 |
| CSS2 | 0.754 | 2.125 | 0.975 | 4.630 | 0.058 |
| CSS3 | 0.759 | 2.135 | 0.661 | 6.899 | 0.205 |
| CSS4 | -19.569 | 0.000 | 0.000 | . | 0.999 |
| NYHA; NYHA I = 1 as references | | | | | |
| NYHA II | 0.399 | 1.490 | 0.752 | 2.953 | 0.253 |
| NYHA III | 1.361 | 3.898 | 1.554 | 9.777 | 0.004 |
| NYHA IV | 23.11 | 1.093 | 0.000 | . | 0.999 |
| Diabetes | -0.123 | 0.884 | 0.492 | 1.590 | 0.681 |
| Hypertension | -0.123 | 0.884 | 0.423 | 1.848 | 0.744 |
| Hyperchlolesterolemia | 0.193 | 1.213 | 0.571 | 2.576 | 0.616 |
| Renal Disease | 0.897 | 2.451 | 1.314 | 4.570 | 0.005 |
| Urgency; Elective = 1 as references | | | | | |
| Urgent | 0.588 | 1.800 | 0.929 | 3.490 | 0.082 |
| Emergency | 1.967 | 7.148 | 1.821 | 28.058 | 0.005 |
| Re-Open Location; OT as references | | | | | |
| ICU | 0.621 | 1.860 | 0.963 | 3.591 | 0.064 |
| Bypass time (min) | 0.007 | 1.007 | 1.003 | 1.010 | 0.002 |
| Cross clamp time (Min) | 0.009 | 1.009 | 1.004 | 1.020 | 0.001 |
| Post-op Stay (Day) | 0.005 | 1.005 | 0.993 | 1.020 | 0.405 |
| Renal Failure Need Dialysis | 2.788 | 16.242 | 8.079 | 3.270 | <0.001 |
| Pulmonary Complication | 1.809 | 6.104 | 3.123 | 1.190 | <0.001 |
| GI Complication | 2.129 | 8.407 | 3.366 | 2.100 | <0.001 |
| Heart Failure | 2.730 | 15.34 | 5.186 | 4.540 | <0.001 |
| Pericardial Effusion | -0.199 | 0.820 | 0.438 | 1.540 | 0.536 |
| Fever | 1.095 | 2.989 | 1.487 | 6.010 | 0.002 |
| Surgical Site Infection | 0.890 | 2.435 | 0.931 | 6.370 | 0.07 |

**Multivariable Predictors of Mortality**
**Dependent variable: Mortality**

| Variable | Univariate Analysis | | | | p-value |
|---|---|---|---|---|---|
| | Beta | Odd Ratio (OR) | 95% Confidence Interval for Difference | | |
| | | | Lower Bound | Upper Bound | |
| Renal failure need dialysis | 3.098 | 22.148 | 9.160 | 5.350 | <0.001 |
| Heart Failure | 1.713 | 5.545 | 1.335 | 2.300 | 0.018 |

exploration were minimal as compared to the patients who survived. There was no significant difference between the types of surgery done in the deceased group.

In comparison on the complications developed in the patients involved, ICU vs OT, from the year 2019 to 2020. there were more patients who developed pericardial effusion post-chest re-exploration in ICU group, whereas most patients in the OT group developed fever. It is also portrayed that the patients of the ICU group had higher percentage of complications for all categories than patients who underwent chest re-exploration in an OT, with a significant p-value <0.001.

The time of chest re-exploration for haemostasis in ICU vs OT in deceased patients from 2019 to 2020 was analysed and is shown in Figure 2. The decision for chest re-exploration was predominantly made <12 hours for both the groups, with ICU being the higher percentage as compared to the OT, followed by 24–48 hours, 12–24 hours, and >48 hours, which involved the least percentage of patients who succumbed. The figure also shows the cause of deaths of patients who underwent chest re-exploration for haemostasis (ICU vs OT). The major cause of death in the patients of the ICU group was myocardial failure, whereas sepsis was for those in the OT group. No patient was deceased because of respiratory failure for those who had chest re-exploration for haemostasis in OT, whereas for the ICU group, respiratory failure had the least percentage.

Tables II showed that patients who developed renal failure needing dialysis post-chest re-exploration contributed 16

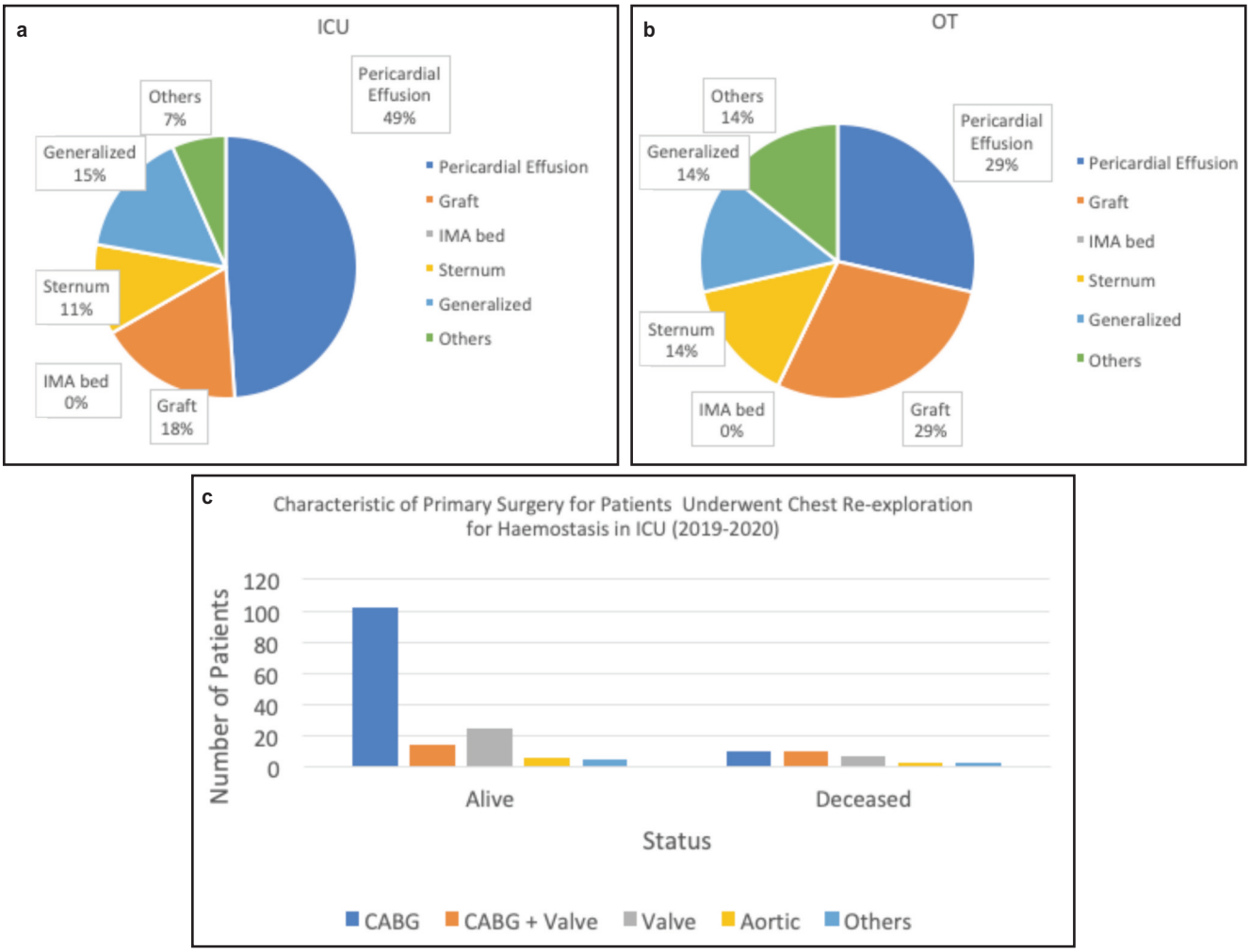


**Fig. 1:** Source of Bleeding/Tamponade Identified During Chest Re-exploration for Deceased Patients in (a) ICU and (b) OT (2019–2020), & Characteristic of primary surgery for patients who underwent chest re-exploration for haemostasis in ICU 2019–2020.

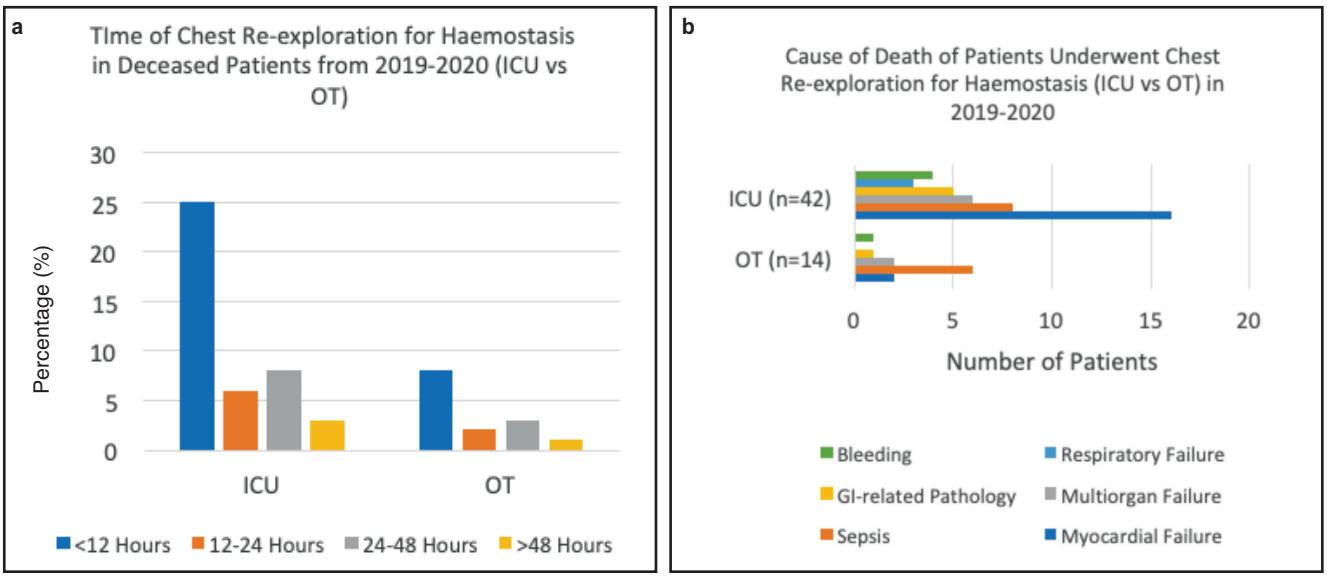


**Fig. 2:** (a) Time of chest re-exploration for haemostasis in deceased patients from 2019 to 2020 (ICU vs OT) & (b) Cause of death of patients who underwent chest re-exploration for haemostasis from 2019 to 2020 (ICU vs OT).

times towards the mortality rate post-chest re-exploration (OR 16.242, CI [8.079, 3.270], p-value < 0.001). Other complications namely pulmonary complication, GI complication, heart failure, and fever also contributed significantly towards the percentage of mortality post-chest re-exploration.

## DISCUSSION

All cases of chest re-exploration for haemostasis were preferred to be conducted in the OT, unless it has to be done immediately, for example, in cases where an active bleeding is suspected, or the patient is hemodynamically unstable to be pushed to the operation theatre, the patient will undergo chest re-exploration in an ICU. From the year 2019 to 2020, 299 out of 4406 cases of open-heart surgery needed chest re-exploration for haemostasis, which accounts to about 6.79%. This percentage is slightly higher than the overall incidence rate of chest re-exploration for bleeding, as reported by Canádyová and Zmeko from Czech Republic, which is about 2.3 to 6%.[2,3-6] This is likely contributed by the fact that our institute is the main cardiothoracic training centre and in comparison to Caucasians, Asians have a higher risk of bleeding, as reported previously.[7]

The results showed that the demographic data and types of primary surgery of patients who underwent chest re-exploration do not contribute significantly towards the patient's outcome. The percentage of death is 8.8% more in patients who underwent chest re-exploration in an ICU rather than an OT, with a p-value of 0.062. Referring to Table 3, all complications showed a higher percentage in those who've had chest re-exploration in ICU as compared to cases conducted in an OT, possibility because of many reasons. Cases of chest re-exploration for haemostasis conducted in an ICU involve patients who are more ill and hemodynamically unstable, for example, suspicion of active bleeding, patients requiring high inotropic support, or any other reasons which disrupt the feasibility of transporting the patient to the OT. Hence, there is high possibility of the involved patients to develop post-operative complications which lead to a higher mortality percentage. Furthermore, an ICU is not a place which is as well-equipped for surgery as compared to an OT, especially in cases which need to be put on cardiopulmonary support in ICU.

There are a few measures that can be taken to improve the outcome of post-chest re-exploration patients, by managing the factors or risk of patients developing complication post-operatively, especially those which are modifiable. We could reduce the risk of bleeding by withholding the anticoagulants in a timely manner as per the guidelines, especially in elective cases. Patients with uncontrolled diabetes, dyslipidaemia and blood pressure should be optimized pre-operatively. To reduce the risk of having pulmonary complication, stable asymptomatic patients who smoke should be given a later date of surgery, where he/she could stop smoking for at least one month. It is also advisable to ensure that the relevant equipment needed for chest re-exploration are complete and reachable in an ICU, to avoid further delay in chest re-exploration or issues during chest re-exploration.

However, with that being mentioned, it is found that the results were not statistically significant, possibly because of the limited sample size and the need to conduct a randomized control trial later. As it is a retrospective analysis, there is also a possibility that biasness is involved.

## CONCLUSION

Chest re-exploration in an ICU setting for post-cardiac surgery patients showed a higher percentage of complications, which contributes to a higher percentage of mortality. However, the results are not statistically significant and follow-up study with a bigger sample size, or a randomized control trial is advisable.

## ACKNOWLEDGEMENT

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