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## MR pelvimetry in prognosis for successful vaginal delivery



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# 1 Abbreviations

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<b>ACOG</b>	American College of Obstetricians and Gynecologists
<b>CPD</b>	Cephalopelvic disproportion
<b>CS</b>	Caesarean section
<b>CT</b>	Computer tomography
<b>CV</b>	Conjugata vera
<b>DGGG</b>	Deutsche Gesellschaft für Gynäkologie und Geburtshilfe
<b>DT</b>	Diameter transversalis
<b>eCS</b>	Elective Caesarean section
<b>FPD</b>	Fetopelvic disproportion
<b>MR</b>	Magnetic resonance
<b>pCS</b>	Planned Caesarean section
<b>RCOG</b>	Royal College of Obstetricians and Gynaecologists
<b>TOL</b>	Trial of labour
<b>tCS</b>	Caesarean Section after trial of labour
<b>uCS</b>	Unplanned Caesarean section
<b>VBAC</b>	Vaginal birth after Caesarean
<b>VD</b>	Vaginal delivery
<b>WHO</b>	World Health Organisation

## 2 List of publications

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### Publication One

Franz M, von Bismarck A, Delius M, et al. MR pelvimetry: prognosis for successful vaginal delivery in patients with suspected fetopelvic disproportion or breech presentation at term. *Arch Gynecol Obstet*. 2017;295(2):351-359.

DOI: 10.1007/s00404-016-4276-6

### Publication Two

von Bismarck A, Ertl-Wagner B, Stoecklein S, et al. MR pelvimetry for breech presentation at term- interobserver reliability, incidental findings and reference values. *Fortschr Röntgenstr*. 2019;191(5):424-432.

DOI: 10.1055/a-0715-2122

## 3 Introduction

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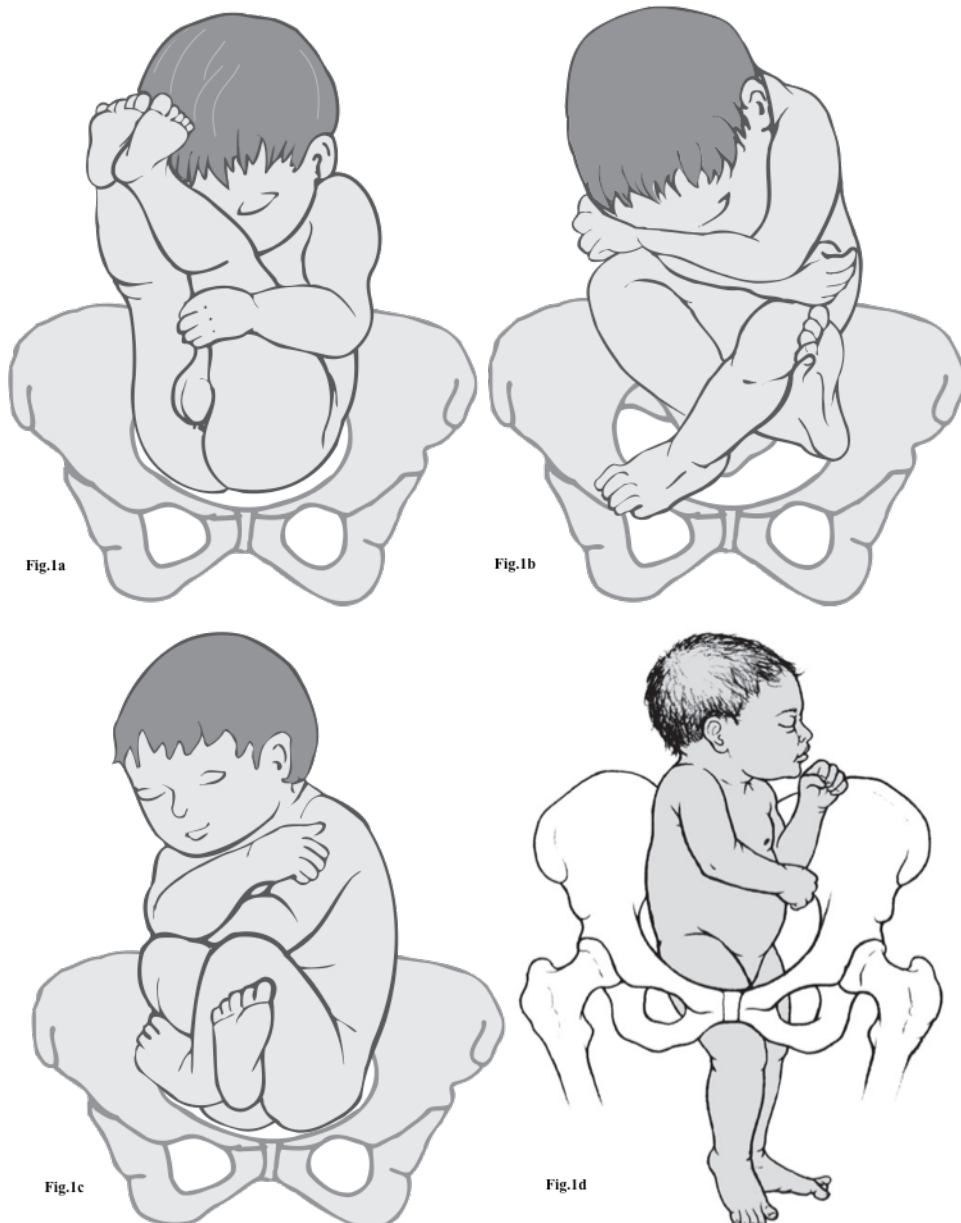
### 3.1 Caesarean Section

Over the past decades caesarean section (CS) rates in general have risen. In Germany, CS rates have more than doubled: While in 1991 only 15.3% of all annual deliveries were CSs,<sup>1</sup> in 2016 the rate had risen to 31.2%<sup>2(p.14)</sup>. Meanwhile, in a critical review of their formerly recommended CS rate of 10-15%, the World Health Organisation (WHO) remarked that ‘at the population level, CS rates higher than 10% are not associated with reductions in maternal and newborn mortality rates’<sup>3</sup>. Articulating doubt about a national target rate for CS this low, Molina et al. instead postulated a benefit to maternal and neonatal mortality of rates of up to 19% among WHO member states.<sup>4</sup> Nevertheless, delivery by CS also increases certain risks for mother and neonate. Immediate post-surgical risks for the mother include haemorrhage, wound infection and delayed hospital discharge.<sup>5</sup> Long-term risks associated with uterine scarring primarily affect subsequent pregnancies and include placentation abnormalities, uterine rupture and repeat-CS.<sup>6</sup> Conversely, neonates delivered by CS reportedly are at greater risk for respiratory morbidity.<sup>7</sup> Therefore, concern that in some cases potential risks associated with CS might outweigh the benefits has directed scientific research toward reassessing indications for and outcomes of CS.<sup>8</sup> Among the most common indications for CS are previous CS or uterine scar, fetus in breech presentation and relative fetopelvic disproportion (FDP)- a mismatch between fetal size and maternal pelvis.<sup>2(p.69)</sup>

### 3.2 Breech Presentation

Breech presentation at term (complete 37-41 weeks of gestation) occurs in about 3-5 % of all pregnancies. Although often referred to as a malpresentation or anomaly, Feige and Krause argued that breech is in fact a normal variation of longitudinal lie and therefore eligible for vaginal birth.<sup>9</sup> Variants of breech presentation are: frank breech (70% of breech cases) with maximal hip flexion and both legs folded up against the fetal torso; incomplete breech (10% of breech cases) with at least one leg flexed at hip and knee; and complete breech (20% of breech cases) with both legs flexed at hip and knee in a squatting position.<sup>9</sup> A footling presentation with at least one fully extended leg leading may occur intrapartially and presents an indication for CS (for illustrations see **Figures 1a-d**). While different risk factors for

persisting breech presentation have been suggested such as lower birth weight, short gestational age, primiparity, older maternal age<sup>10</sup> and cornu-fundal implantation of placenta<sup>11</sup>, no causal relationship has been established. In the absence of contraindications, the obstetrician in charge will often offer manual external cephalic version, whose reported success rates vary between 50%<sup>12</sup> and 68%<sup>13</sup>. Data regarding the effectiveness of moxibustion and acupuncture remain ambiguous, indicating greatest success when combined.<sup>14</sup>



**Figures 1a-d.** Variants of breech presentation: a) frank breech, b) incomplete breech, c) complete breech, and d) (intrapartal) footling.

Source: Feige A, Krause M. Beckenendlage Abb. 43.1+ 43.3-5. In: Schneider H, ed. *Die Geburtshilfe*. DOI: 10.1007/978-3-642-12974-2\_43 [images] Published 2011. Retrieved from LMU E-Medien Universitätsbibliothek OPAC eBook database. [Accessed May 10, 2017]



Vaginal breech delivery represents an obstetric challenge as it carries certain risks in comparison to the delivery of a fetus in vertex presentation. During regular labour, the largest fetal part, the head, continually stretches the cervix, thereby augmenting contractions and also occluding the entire cervical opening. In breech presentation, on the other hand, particularly with non-frank presentations, the leading fetal part exerts less pressure on the cervix, thereby weakening contractions and increasing the risk of prolonged labour. Furthermore, the leading fetal part usually does not occlude the cervical circumference completely, increasing the risk of umbilical cord or extremity prolapse and subsequent caesarean section. As fetal growth restriction (<10<sup>th</sup> percentile) can exacerbate these risks, delivery by caesarean section is recommended in such cases.<sup>12</sup> Because the large fetal head is delivered last, risks for head entrapment and ensuing cord compression, asphyxia, hypoxic intracerebral haemorrhage, lower five-minute APGAR and lower cord blood pH are also increased.<sup>15</sup> During delivery through the maternal pelvis the fetus's arms may flap up, increasing the risk of brachial plexus injury.<sup>16</sup> Other possible traumatic injuries include fractures, haematomas and intracranial haemorrhage. Bearing in mind that 'total breech extraction is [considered] inappropriate for term singleton breech delivery' and that 'fetal traction should be avoided'<sup>15</sup>, when indicated, the obstetrician in charge may assist vaginal breech delivery by performing certain manoeuvres<sup>17</sup> such as Løvset or Bickenbach to reduce nuchal arms or Veit-Smellie or Bracht to deliver the after-coming head.<sup>15</sup> With rising caesarean section rates obstetricians with the manual skills required for vaginal breech delivery have rarefied,<sup>18</sup> further reducing its availability.

Aiming at minimising risks, guidelines for planned vaginal breech delivery have been stipulated. Concurring on the relevant factors for a trial of labour, the *Deutsche Gesellschaft für Gynäkologie und Geburtshilfe* (DGGG)<sup>19(p.4)</sup>, the *Royal College of Obstetricians and Gynaecologists* (RCOG)<sup>12</sup> and the *American College of Obstetricians and Gynecologists* (ACOG)<sup>20</sup> listed the following contraindications: estimated fetal weight below the tenth percentile or above 3.8- 4 kg, hyperextended neck, footling presentation, maternal pelvic deformity, and antenatal fetal compromise or anomaly. Extending their lists of unfavourable conditions, the DGGG added a fetal head circumference being much larger than the abdominal circumference<sup>19(p.4)</sup>, while the ACOG added a gestational age smaller than 37 weeks<sup>20</sup>. Reaffirming its 2006 Committee Opinion in 2016, the ACOG stated vaginal breech delivery to be 'reasonable under hospital-specific protocol guidelines for both eligibility and labor management'<sup>20</sup>.

Still, due to the particular risk profile, preferred mode of delivery in case of persistent breech presentation has been controversially discussed. In 2000, findings of the Term Breech Trial, an international, randomised controlled trial, were published, stating significantly greater neonatal morbidity and mortality with vaginal breech delivery in comparison to planned caesarean section and thus recommending only the latter.<sup>21</sup> A blunt paradigm shift in the obstetric management of breech cases ensued until criticism of the trial's methodology as well as its generalised recommendation for planned caesarean section arose.<sup>22-24</sup> Since then vaginal breech delivery has remained contentious and planned caesarean section continues to be the predominant mode of delivery for breech presentation as shown in **Table 1**. In 2015, German national statistics reported that of all fetuses in breech presentation at term, 66.6% were delivered via caesarean section.<sup>2</sup> Comparably, Lee et al. found that in 2003, more than 85% of all breech cases in the United States were delivered via caesarean section<sup>25</sup>; and Lansac et al. reported a stable total caesarean section rate for breech cases of 76% in France between 2005-2010.<sup>26</sup> Considering associated risks of maternal and fetal morbidity, high caesarean section rates demand scientific scrutiny.

**Table 1.** Comparison of modes of delivery between cases with fetus >1500g in breech and in vertex presentation in Germany in 2016 according to the Institut für Qualitätssicherung und Transparenz im Gesundheitswesen, percentages given

	Fetus >1500g in breech presentation (%)	Fetus >1500g in vertex presentation (%)
Primary caesarean section	57.7	10.9
Secondary caesarean section	30.2	14.6
Vaginal delivery	6.6	64.9
Vaginal-operative	2.3	7.3
Other	3.2	2.3

Source: Institut für Qualitätssicherung und Transparenz im Gesundheitswesen. Bundesauswertung zum Erfassungsjahr 2016: Geburtshilfe. Available at: [https://www.iqtig.org/downloads/ergebnisse/bundesauswertung/2016/indirekte\\_verfahren/QSKH\\_16n1-GEbH\\_2016\\_BUAW\\_V02\\_2017-07-12.pdf](https://www.iqtig.org/downloads/ergebnisse/bundesauswertung/2016/indirekte_verfahren/QSKH_16n1-GEbH_2016_BUAW_V02_2017-07-12.pdf). pp.66-67. Published 2017. [Accessed Nov. 10, 2017]

### 3.3 Cephalopelvic and Fetopelvic Disproportion

Cephalopelvic disproportion (CPD), or fetopelvic disproportion (FPD) in non-vertex presentation, refers to a disparity between maternal pelvis and fetal head. It has been argued that increasing CS rates have tampered with ‘natural’ obstetric selection, leading to an evolutionary upsurge of fetopelvic disproportion- in itself an indication for CS.<sup>27</sup> Further distinction is made between relative and absolute CPD. Absolute CPD signifies a definitive incongruence caused either by an inadequately small maternal pelvis or a large fetus or both, rendering vaginal delivery impossible; relative CPD, on the other hand, is caused by malposition or malpresentation of the fetal head, which may be overcome in vaginal delivery.<sup>28</sup> In 2016, German national statistics reported that of all singleton cephalic term pregnancies 2.6% were diagnosed with relative CPD, of which 91.6% of fetuses were delivered via caesarean section.<sup>2(p.68)</sup> Analysing risk factors associated with CPD, Tsvieli et al. found significant association with fetal macrosomia, infertility treatment, previous caesarean section, maternal obesity, and polyhydramnios.<sup>29</sup> However, no causality has been established.

While the definition of CPD may be clear, the diagnosis is often more difficult. As the accuracy of prepartal fetal weight estimation by sonography has been found to vary,<sup>30</sup> especially in cases of breech presentation,<sup>31</sup> its reliability in prepartal assessment toward a mode of delivery has been questioned. Also the mouldability of the fetal head adds some uncertainty: depending largely on the efficacy of uterine contractions, this element remains unknown until active labour. For these reasons, it has been argued that CPD can only be diagnosed after an ‘adequate trial of labour’<sup>28</sup>. In standard obstetric management, the maternal pelvis is gaged through manual examination. This method, however, is limited to a few pelvic diameters and less accurate<sup>32</sup> than radiographic methods.

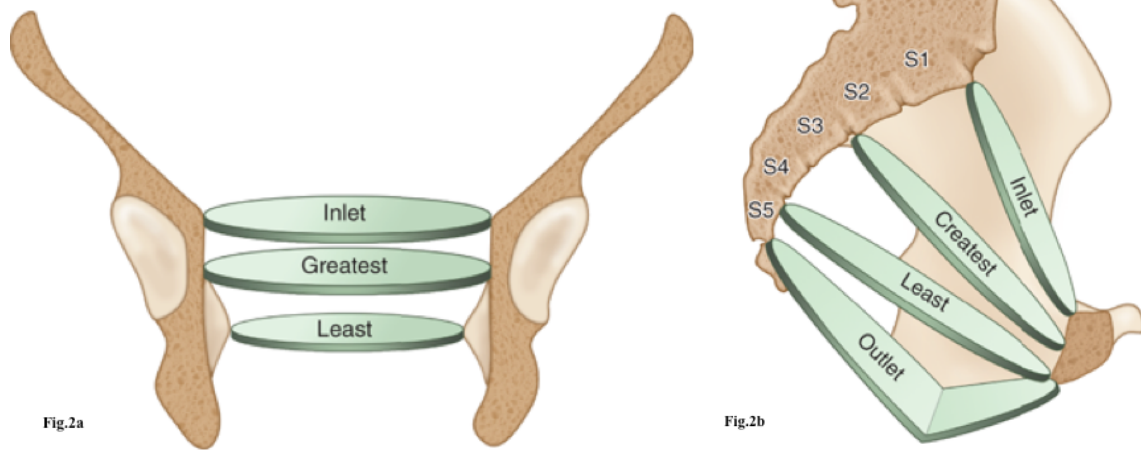
Delivery complicated by CPD carries an increased risk for adverse outcomes such as cervical laceration, uterine rupture, intrapartum mortality, and low 1-min APGAR score.<sup>29</sup> Furthermore, the diagnosis of CPD often has consequences for future deliveries. Although much recent research has concentrated on the chances and risks of vaginal birth after caesarean (VBAC), women with a history of caesarean section due to CPD will frequently have a repeat-caesarean section instead of a VBAC. Challenging this practice, Impey et al. found that 68% of women who delivered their first child by CS due to CPD had a successful VBAC.<sup>33</sup>

### 3.4 MR Pelvimetry

Key determinants for vaginal delivery are often summarised and conveyed as the ‘three Ps of labour’: power (contractions), passenger (fetus), and passageway (maternal pelvis). In most cases of uncomplicated pregnancy and labour, cardiotocography, fetal ultrasound and manual pelvic assessment are sufficient to monitor pregnancy and labour progress. Cases of suspected fetopelvic disproportion or persistent breech presentation, however, may warrant more diagnostic detail, when deciding on a mode of delivery. Antepartal MR pelvimetry can be performed to provide objective information about maternal pelvic dimensions that cannot be accurately obtained by manual examination.<sup>34</sup> With the aim to improve patient selection for a trial of labour and to reduce labour arrest and subsequent caesarean section caused by inadequacy of the pelvic ‘passageway’, many studies have concentrated on the potential of antepartal MR pelvimetry in the prognosis of vaginal delivery.<sup>34-41</sup>

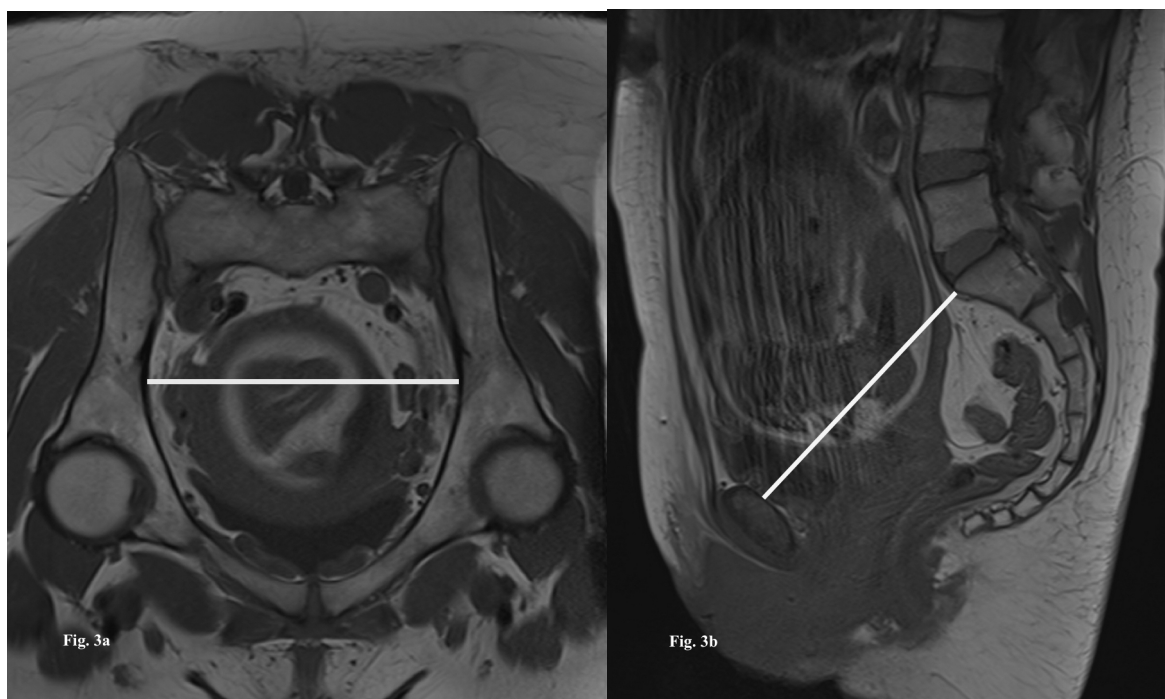
Since MR imaging does not use ionising radiation associated with fetal teratogenesis and carcinogenesis, MR has been established as the preferred pelvimetry imaging method during pregnancy over X-ray and computer tomography (CT).<sup>42</sup> Recent studies have further extended research into possible risks of antepartal MR imaging such as potential teratogenic effects through localised tissue heating caused by electromagnetic wave energy deposition<sup>43</sup> and potential acoustic impairment through noise exposure<sup>44</sup>. Yet neither study found adverse effects to the fetus or neonate associated with antenatal MR pelvimetry. Thus, antepartal MR pelvimetry in the last trimester remains to be considered safe for mother and fetus.<sup>45</sup>

The female ‘true’ bony pelvis- the focus of pelvimetric evaluation- can be divided into three sections (from cranial to caudal): the inlet, the mid-pelvis, and the outlet (illustrated in **Figure 2a+b**). Among these, numerous pelvimetric parameters have been defined.<sup>42</sup> Standard obstetric MR pelvimetry often includes two parameters of the pelvic inlet: the conjugata vera obstetrica (CV), the shortest distance measured from the posterior edge of the cartilaginous symphysis pubis to the superior anterior aspect of the sacral promontory; and the diameter transversalis (DT), the largest transverse distance of the pelvic inlet measured on level with the femoral heads (as outlined in **Figure 3a+b** and **4**).<sup>46,47</sup>



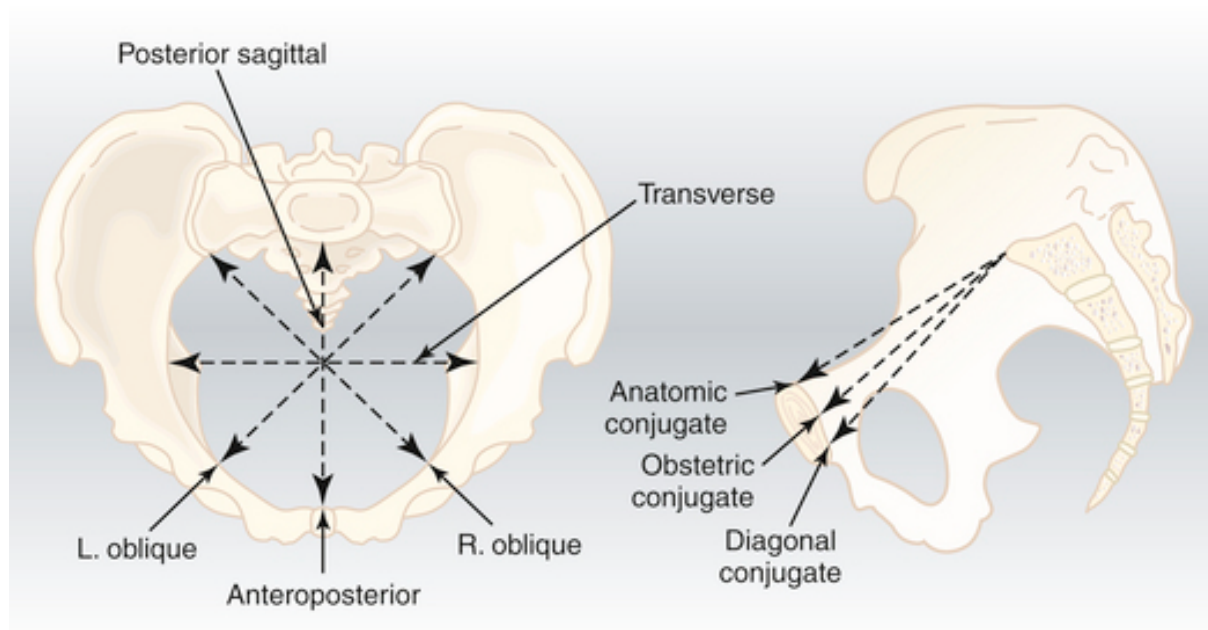
**Figure 2a+b.** Planes of the true pelvis, a) in coronal plane, b) in sagittal plane

Source: Posner GD. Obstetric Pelvis Fig. 5-2 A+B Pelvic Planes. In: Posner GD, Black AY, Jones GD, Dy J, eds. *Human Labor and Birth*. [images] Published 2013. Available at: <https://obgyn.mhmedical.com/content.aspx?bookid=1247&sectionid=75161489>. [Accessed Mar. 13, 2017]



**Figure 3a+b.** MR pelvimetry, a) diameter transversalis in transverse plane, b) conjugata vera in midsagittal plane

Source: Obstetric MR pelvimetry. (n.d.). [images] Picture archiving and communication systems (PACS) of the Department for Clinical Radiology, Ludwig-Maximilians-Universität, München. Also used in: von Bismarck A, Ertl-Wagner B, Stoecklein S, et al. MR pelvimetry for breech presentation at term- interobserver reliability, incidental findings and reference values. *Fortschr Röntgenstr.* 2018;190:1-9. DOI: 10.1055/a-0715-2122



**Figure 4.** Parameters of the pelvic inlet in axial view (left) and midsagittal view (right). *Transverse* diameter transversalis, *obstetric conjugate* conjugata vera obstetrica

Source: Hobel C, Zakowski M. Normal Labor, Delivery, and Postpartum Care Fig. 8-3 Pelvic inlet and its diameters. In: Hacker NF, Gambone JC, Hobel C, eds. *Essentials of Obstetrics and Gynecology*. [image] Published 2015. Available at: <http://clinicalgate.com/normal-labor-delivery-and-postpartum-care/>. [Accessed Feb. 7, 2017]

Scientific literature has been divided over the role of MR pelvimetry in cases of breech presentation. Berger et al. set fetal breech diameters in relation to maternal pelvic inlet diameters and found resulting ratios to be useful in the prognosis of vaginal breech delivery.<sup>37</sup> In a randomised controlled trial, van Loon et al. investigated the impact of antepartal MR pelvimetry on mode of delivery, concluding that knowledge of pelvic measurements did not affect the overall caesarean section rate, but it did significantly reduce the rate of emergency caesarean sections.<sup>38</sup> In a similar vein, the PREMODA study ascribed its favourable vaginal delivery rate of 71%, compared to 61% in the Term Breech Trial, in part to its considerably higher rate of antepartal pelvimetry of 82.5% of trial of labour cases, compared to 9.8% in the Term Breech Trial.<sup>48</sup> Jeyabalan et al. found significantly less neonatal morbidity after vaginal breech delivery when antepartal CT pelvimetry was added to the standard clinical work-up.<sup>49</sup> These promising results, however, have also been challenged. Commenting on van Loon's study, Griffiths lamented the lack of established reference values for MR pelvimetry and concluded that MR pelvimetry was ill-suited for multiparous women and that the success of vaginal delivery was influenced by obstetrician's confidence in vaginal delivery.<sup>50</sup>

Responding to a letter supportive of MR pelvimetry, Bisits deemed pelvimetry's part in the success of the PREMODA study to be likely overrated, and summarised that there was no reduction in adverse outcomes through pelvimetry, fetopelvic algorithms showed little promise in predicting labour outcome, and that labour progress was still the best indicator in vaginal breech birth.<sup>51</sup>

Concerning cases of suspected cephalopelvic disproportion, data about the usefulness of MR pelvimetry also remains debated. Due to lacks of sensitivity or specificity, Spörri et al. dismissed eight different techniques to identify CPD and predict labour outcome, proposing instead research into the pelvic outlet.<sup>52</sup> However, comparing patients with vaginal and vaginal-operative deliveries, Korhonen et al. found the pelvic outlet to bear no significant difference between the groups.<sup>53</sup> Initially proposed by Morgan et al.,<sup>54</sup> the fetal-pelvic index (FPI), derived from subtracting fetal circumferences from maternal pelvic circumferences, was received with disappointment by some,<sup>36,55</sup> yet with encouragement by others.<sup>40,56</sup>

Investigating the predictive value of CT and X-ray pelvimetries, respectively, Lenhard et al.<sup>57</sup> and Harper et al.<sup>35</sup> both found receiver operator characteristics curves of 0.88 for the midpelvic sagittal diameter, concluding this parameter a 'useful adjunct [...] in the determination of who should attempt a vaginal delivery'<sup>35</sup>. Sibony et al. reported the transverse diameter of the inlet to be informative in the selection of VBAC candidates.<sup>58</sup> Keller et al. found all five pelvimetric parameters (obstetric conjugate, interspinous distance, intertuberous distance, transverse diameter, sagittal outlet) to be significantly smaller in the group of secondary caesarean section and assisted delivery due to FPD compared to the vaginal delivery group.<sup>59</sup>

Attempts to determine pelvic norm values<sup>59</sup> and threshold values for successful vaginal delivery<sup>60</sup> have been made. Yet, to this point, no unanimously accepted guidelines for clinical application or reference values for vaginal delivery have been established.

As antepartal MR pelvimetry and its interpretation require collaboration between radiologists and obstetricians, some researchers sought to examine interobserver reliability between the two specialties. In the second part of their study, Keller et al. prospectively analysed inter- and intraobserver reliability among four radiologists and one obstetrician, revealing strong agreement with all pelvimetric parameters except for the intertuberous distance and the sagittal outlet.<sup>59</sup> Similarly, in a retrospective study, Korhonen et al. demonstrated

interobserver agreement between radiologic and obstetric reports.<sup>61</sup> So far, however, breech cases have mostly been excluded from these investigations and varying levels of clinical experience of the MR readers were ignored.

### **3.5 Study Purpose**

In the absence of universally accepted and established guidelines, the role of MR pelvimetry in the selection of women for a trial of labour remains contested. It is clinical practice at the Perinatalzentrum Grosshadern, LMU Munich, that pregnant women with risk factors that could complicate vaginal delivery such as suspected fetopelvic disproportion or fetal breech presentation at term will be offered antepartal MR pelvimetry to assess the maternal pelvis. Our study group focussed on examining the role of MR pelvimetry in the selection of women for a trial of labour. Ideally, MR pelvimetry might help identify cases of pelvic inadequacy and thereby prevent prolonged labour, dystocia and subsequent unplanned caesarean section due to mechanical disparity. On the other hand, MR pelvimetry might also ease qualms about pelvic inadequacy in cases of fetal breech presentation and in cases of previous unplanned caesarean section after complicated labour, thereby reducing the rate of potentially unnecessary planned caesarean sections by offering a choice of delivery mode, whenever possible. Improved selection criteria might alleviate a priori scepticism about vaginal breech delivery and instead reestablish it as a viable delivery option, thereby also preserving those essential obstetric skills.

Included in this cumulative work are two recent publications by our study group. The first study<sup>46</sup> aimed to investigate the prognostic value of antepartal MR pelvimetry for successful vaginal delivery in a high-risk collective consisting of cases of suspected fetopelvic disproportion and breech presentation at term. To this end, pelvimetric inlet measurements and fetal outcomes were retrospectively compared among different groups of delivery.

The second study<sup>47</sup> concentrated exclusively on women with fetus in breech presentation at term for a more homogenous study collective. As antepartal MR pelvimetry represents a juncture of radiologic and obstetric collaboration and expertise and in order to examine the robustness of MR pelvimetry in the clinical setting, we investigated interobserver reliability of pelvimetric measurements between and among radiologists and obstetricians with different levels of clinical experience. Incidental findings noted by the observers during MR evaluation



were reviewed and appraised. As the viability of vaginal breech delivery remains a much-debated topic, potential pelvic reference values were assessed.

### **3.6 Author's Contribution**

In the first publication the doctoral candidate is listed as the second co-author. Initially conceptualised by Prof. Dr. med. Uwe Hasbargen, Prof. Dr. med. Birgit Ertl-Wagner and Dr. med. Marie Franz, the doctoral candidate joined the study group in November 2015. She then took part in finalising the study aims and design. The acquisition and recording of data from radiological and obstetric databases as well as from hospital archives on the one hand and quality control and management of data and algorithms on the other represented tasks completed independently by the doctoral candidate. All MR sequences included in the study were pelvimetrically reassessed by the candidate. Statistical analysis was done in collaboration with Dr. med. Marie Franz and reviewed by Prof. Dr. med. Uwe Hasbargen, Dr. med. Maria Delius, Dr. med. Christoph Hübener and Mrs. Regina Schinner. The manuscript including tables and figures was prepared independently by the doctoral candidate and subsequently reviewed in conjunction with Dr. med. Marie Franz; requests for revision by the publisher were addressed and implemented by both and then reviewed by Dr. med. Christoph Hübener.

In the second publication the doctoral candidate is listed as the sole first author. The idea of an interobserver study was proposed by the doctoral candidate and developed further with Prof. Dr. med. Birgit Ertl-Wagner, Prof. Dr. med. Uwe Hasbargen and Dr. med. Marie Franz. After training and instructions from Prof. Dr. Ertl-Wagner regarding pelvimetric measurement and operating the radiologic workstation, the doctoral candidate introduced observers to the study protocol and MR pelvimetry measuring standards; she supervised all evaluation sessions and recorded all data. Statistical analysis and data interpretation were prepared independently by the doctoral candidate and reviewed by Prof. Dr. med. Uwe Hasbargen, Dr. med. Marie Franz and Mrs. Regina Schinner. The manuscript including tables and figures was prepared by the doctoral candidate and primarily reviewed by Dr. med. Marie Franz; again, requests for revision by the publisher were addressed and implemented by both.

## 4 Publications

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### 4.1 Publication One

Franz M, von Bismarck A, Delius M, et al. MR pelvimetry: prognosis for successful vaginal delivery in patients with suspected fetopelvic disproportion or breech presentation at term. *Arch Gynecol Obstet*. 2017;295(2):351-359.

<https://link.springer.com/article/10.1007%2Fs00404-016-4276-6>

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## **4.2 Publication Two**

von Bismarck A, Ertl-Wagner B, Stoecklein S, et al. MR pelvimetry for breech presentation at term- interobserver reliability, incidental findings and reference values. *Fortschr Röntgenstr.* 2019;191(5):424-432.

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## 5 Summary

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### 5.1 Summary

Antepartal MR pelvimetry is used to measure and assess the maternal pelvis when fetal breech presentation or suspected fetopelvic disproportion may impede vaginal delivery. Still lingering scepticism surrounding the usefulness and clinical application of antepartal MR pelvimetry persists. Therefore we dedicated our research to examining the prognostic value of MR pelvimetry in the selection of women for a trial of labour on the one hand, and the interobserver reliability of MR pelvimetric measurements between radiologists and obstetricians on the other.

Focussing on the prognostic value of MR pelvimetry in trial of labour candidates, the first study<sup>46</sup> showed significantly smaller pelvic inlet measurements in planned caesarean section patients compared to trial of labour candidates. Yet, women with a successful vaginal delivery and women with an unplanned caesarean section after a failed trial of labour did not differ significantly in pelvic inlet measurements. This finding might be explained by the retrospective nature of the study: Pelvimetrically inadequate cases were selected for pCS, eliminating most small pelvises as potential cause for failure to progress in second stage of labour; and leaving other causes such as fetal distress and failure to progress in first stage of labour, which arguably cannot be predicted by pelvimetry.

Regarding cases of breech presentation, we found lower caesarean section rates compared to the rates reported by the Term Breech Trial<sup>21</sup>, which stated use of antepartal radiologic pelvimetry in merely 9.8 % of trial of labour cases. Due to a lack of prospective studies investigating fetopelvic disproportion cases, we could not adequately compare our caesarean section rates of this collective with rates of others. At hospital discharge, no neonatal mortality or serious morbidity was found. Our findings suggest MR pelvimetry to be a useful tool when selecting patients with fetus in breech presentation or with suspected fetopelvic disproportion for a trial of labour. However, for women with a previous vaginal delivery MR pelvimetry does not seem to yield additional predictive value.

Concentrating on women with fetus in breech presentation, the second study<sup>62</sup> assessed the interobserver reliability of MR pelvimetric measurements between and among radiologists and obstetricians with different levels of clinical experience. In addition, reference values for vaginal breech delivery and incidental findings noted during MR evaluation were examined.

Irrespective of specialisation and level of clinical experience, interobserver agreements of both pelvic inlet parameters were strong throughout the study. All incidental findings noted in this cohort were judged to be benign, requiring no further clinical attention. Conjugata vera measurements were significantly larger in women with vaginal delivery compared to women with recommended caesarean section, emphasising the utility of this pelvimetric parameter; measurements of diameter transversalis added no information to the prognosis of vaginal delivery. It must be stressed that the proposition of 12.0 cm as a reference value for conjugata vera should be interpreted as an approximation. We would welcome further prospective studies to confirm our findings.

Study limitations included a potential selection bias due to the retrospective and monocentric study design. The decision on a mode of delivery is influenced by various factors including maternal and fetal health, fetal size, maternal preference, skills, experience and availability of the obstetrician. Therefore the assessment of the significance of the maternal pelvis among other factors is rendered difficult. Furthermore, experience and skills required for safe vaginal breech delivery are hard to objectify, which in turn complicates the comparability of data from different perinatal centers.

Despite these limitations, our data supports the usefulness of antepartal MR pelvimetry when selecting women without a previous vaginal delivery for a trial of labour. Having focussed primarily on the pelvic inlet, we would advocate for future research concentrating on the midpelvis<sup>63</sup> and the sacral volume.

## 5.2 Zusammenfassung

In Fällen, in denen eine vaginale Geburt durch eine persistierende Beckenendlage oder ein mögliches fetopelvines Missverhältnis erschwert werden könnte, wird die antepartale MR Pelvimetrie genutzt, um das mütterliche Becken zu vermessen und zu beurteilen. Dennoch besteht weiterhin Skepsis gegenüber der Nützlichkeit sowie der klinischen Anwendung dieses diagnostischen Tools. Daher widmeten wir unsere Forschung zum einen der Frage nach dem prognostischen Wert von MR Pelvimetrie in der Auswahl von Schwangeren für einen vaginalen Geburtsversuch und zum anderen der interobserver Übereinstimmung von pelvimetrischen Messungen durch Radiologen und Geburtshelfer.

Bei der Frage nach dem prognostischen Wert von MR Pelvimetrie für mögliche Kandidaten eines Geburtsversuches zeigte die erste Studie<sup>46</sup> signifikant kleinere Beckeneingangsmaße bei Schwangeren mit geplantem Kaiserschnitt als bei Schwangeren mit Geburtsversuch. Jedoch zeigte sich kein signifikanter Unterschied der Beckenmaße zwischen Frauen mit erfolgreicher vaginaler Geburt und Frauen mit sekundärem Kaiserschnitt. Dieses Ergebnis ließe sich vermutlich durch das retrospektive Studiendesign erklären: Pelvimetrisch inadäquate Fälle wurden direkt für einen geplanten, primären Kaiserschnitt selektiert, wodurch kleine Becken als Grund für einen Geburtsstillstand in der Austreibungsphase praktisch eliminiert wurden; andere potenzielle Gründe für einen sekundären Kaiserschnitt wie fetaler Disstress oder Geburtsstillstand in der Eröffnungsphase blieben bestehen, da diese nicht von Pelvimetrie prognostiziert werden können.

In Bezug auf Fälle mit Fetus in Beckenendlage fanden wir niedrigere Kaiserschnitttraten als der Term Breech Trial<sup>21</sup>, in welchem antepartale radiologische Pelvimetrie in nur 9.8% der Geburtsversuche zum Einsatz kam. Aufgrund des Mangels an prospektiven Studien von Fällen mit fetopelvinem Missverhältnis war es uns nicht möglich die Kaiserschnitttraten unseres Studienkollektivs adäquat mit anderen zu vergleichen. Unsere Forschungsergebnisse deuten daraufhin, dass MR Pelvimetrie ein nützliches Hilfsmittel darstellt, um Schwangere mit fetaler Beckenendlage oder dem Verdacht auf fetopelvines Missverhältnis für einen Geburtsversuch zu selektieren. Allerdings scheint MR Pelvimetrie für Frauen, die bereits vaginal entbunden haben, keinen zusätzlichen prädiktiven Wert zu erbringen.

Mit Schwerpunkt auf Frauen mit Fetus in Beckenendlage untersuchte die zweite Studie<sup>62</sup> die interobserver Übereinstimmung von MR pelvimetrischen Messungen zwischen und unter Radiologen und Geburtshelfern mit unterschiedlichen Graden klinischer Erfahrung. Zusätzlich wurden mögliche Referenzwerte für eine vaginale Beckenendlagegeburt erörtert sowie Nebenbefunde der MR Auswertung evaluiert. Unabhängig von Facharztausbildung und Erfahrungsgrad zeigte sich eine starke interobserver Übereinstimmung in Messungen beider pelvimetrischer Parameter. Alle Nebenbefunde dieses Studienkollektivs wurden als benigne beurteilt und bedurften keiner weiteren klinischen Abklärung. Conjugata-vera-Messungen waren signifikant größer bei Frauen, die vaginal entbinden konnten, als bei Frauen, denen ein primärer Kaiserschnitt empfohlen wurde, was wiederum die Nützlichkeit dieses pelvimetrischen Parameters unterstreicht; die Messungen des Diameter transversalis gaben keinen Aufschluss bezüglich der Prognose einer vaginalen Geburt. Wir möchten darauf hinweisen, dass der Vorschlag von 12.0 cm als Grenzwert für die Conjugata vera als Annäherung aufgefasst werden sollte. Wir würden weitere prospektive Studien begrüßen.

Einschränkend beinhaltet unsere Studie einen Selektionsbias aufgrund des retrospektiven und monozentrischen Studiendesigns. Die Entscheidung für einen bestimmten Geburtsmodus wird von zahlreichen Faktoren wie mütterlichem und fetalem Gesundheitszustand, fetaler Größe, mütterlicher Präferenz, sowie Fähigkeiten, Erfahrung und Verfügbarkeit des Geburtshelfers beeinflusst. Die genaue Bedeutung des maternalen Beckens vis-à-vis anderer Faktoren ist daher schwierig zu bestimmen. Des Weiteren sind klinische Erfahrung und Fähigkeiten, die für eine sichere vaginale Beckenendlagenentbindung notwendig sind, schwer zu objektivieren, was wiederum die Vergleichbarkeit von Daten unterschiedlicher Perinatalzentren verkompliziert.

Trotz dieser Einschränkungen unterstützen unsere Studienergebnisse die Nützlichkeit von antepartaler MR Pelvimetrie, um Frauen, die bisher keine vaginale Geburt hatten, für einen Geburtsversuch zu selektieren. Da unsere Studien sich vorrangig auf die Beckeneingangsebene konzentrierten, würden wir zukünftige Forschungsarbeiten begrüßen, die sich der Beckenmitte<sup>63</sup> wie dem Sakralvolumen annähmen.

## 6 Literature

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