14.1 Clinical Background

Arrest of labor with the necessity of performing secondary cesarean section is a major cause of maternal morbidity and mortality. The fetus is likewise affected by prolonged labor. Pelvimetry is performed to identify those women in whom an attempt at vaginal delivery is likely to fail due to a narrow pelvis or pelvic anomaly. Hence, the clinical significance of pelvimetry depends on how the following questions are answered:

- Is primary cesarean section associated with a lower morbidity and mortality of mother and child than secondary cesarean section after arrested labor has been diagnosed?
- Can arrested labor be treated effectively?
- Is there a reproducible method of pelvimetry with few side effects?
- Is there evidence from randomized and controlled studies that pelvimetry improves maternal and/or fetal outcome?

14.1.1 Primary versus Secondary Cesarean Section

The aim of pelvimetry is to identify maternal pelvic deviations that preclude vaginal delivery or would considerably prolong labor. If the results of pelvimetry suggest that vaginal delivery would be very difficult, primary cesarean section should be suggested. Both the mother and infant can thus be spared secondary cesarean section after protracted labor. The clinical significance of pelvimetry crucially depends on whether primary cesarean section can reduce maternal and fetal morbidity as compared with secondary cesarean section.

Cesarean section is performed as a primary (scheduled) or secondary (non-scheduled, after failure of labor to progress) procedure. The total number
of cesarean sections, i.e. the sum of primary and secondary interventions, is 15%–30% in western industrialized countries. The mortality risk associated with vaginal delivery and cesarean section was determined in a study in Bavaria by Welsch [1].

Cesarean section mortality attributable to the intervention is defined as the number of deaths occurring per 1000 cesarean sections during or within 42 days of the intervention and that are due to surgical or anesthesia-related complications in women who were healthy before the operation and had no pregnancy-related risks. In the survey by Welsch, the maternal mortality risk of vaginal delivery versus cesarean section was 1:2.3 for the period from 1995 to 2000. However, the mortality rates no longer differ if only elective cesarean sections are compared with vaginal deliveries.

These figures underline that secondary cesarean sections after protracted labor or arrest of labor account for the excessive mortality of women during delivery.

Prolonged labor or arrest may have further adverse effects on mother and child:

- **Perinatal Morbidity and Mortality:** The duration of labor, in particular of the second stage, correlates with a decrease in fetal pH and pO₂ and an increase in pCO₂. Although fetal death during delivery has become rare, asphyxia contributes to perinatal morbidity. Detachment of the placenta due to uterine hyperactivity occurs in 1% of all pregnancies. Protracted labor often ends in vaginal operative delivery with the risk of fetal injury.

- **Maternal Morbidity:** Protracted labor involves numerous complications for the mother. Rupture due to overextension of a uterus not operated on before is nearly always due to excessively prolonged labor. The higher need for vaginal operative delivery in women with protracted labor is associated with a higher rate of maternal injuries, pain, hematomas, urinary retention, and anemia as compared with spontaneous delivery [2]. Women with prolonged labor and secondary cesarean section have an increased risk of infection or puerperal fever. Atonic postpartum hemorrhage is a characteristic of long labor and again increases the risk of protracted recovery and infectious complications.

- **Birth Experience:** No adequate systematic data is available on the emotional stress associated with prolonged and traumatic labor with secondary cesarean section. However, many women have problems coping with such an experience and do not become pregnant again.

In summary, prolonged labor and secondary cesarean section bear a considerable risk of maternal morbidity and mortality and also increase fetal morbidity. Modern obstetrical management therefore aims to ensure uncomplicated and speedy spontaneous delivery or, in women where this goal seems unattainable (or is not the mother’s preferred option), to plan elective primary cesarean section beforehand. Hence, techniques that can predict the probability of an uncomplicated vaginal delivery before the onset of labor are of the utmost clinical significance.

### 14.1.2 Can Arrested Labor Be Treated Effectively?

Normal delivery is based on the complex interaction of maternal factors, fetal properties, and adequate labor. If this interaction of “Passages, Passenger, and Powers” is disturbed, labor is protracted or even arrested. The failure of labor to progress is therefore not a diagnosis but a symptom that is amenable to treatment (e.g. when caused by inadequate uterine contractions) or not (e.g. absolute cephalopelvic disproportion). Isolated evaluation of either of the three factors, passages, passenger, and powers, is of limited value as, for instance, cephalopelvic disproportion can be diagnosed only if one looks at both the maternal pelvis and the fetus (“this pelvis is too small for this fetus”).

### 14.1.3 Abnormal Length of Labor: Diagnosis and Causes

#### 14.1.3.1 Diagnosis

The onset of delivery is most commonly defined as the occurrence of regular and painful uterine contractions that result in progressive dilatation and effacement of the cervix.

The course of delivery is determined by the following variables:

- Size and shape of the maternal pelvis
- Flexibility of the maternal soft tissues in the pelvis, adaptation of the ligaments and bony pelvis to the fetus
- Remodeling of the cervix
- Regular birth mechanism of the fetus
- Fetal head molding
- Efficient uterine contractions
The results reported by Friedman in the 1950s still serve as the basis for diagnosing delayed labor [3, 4]. Arrest of labor during the first stage (the stage of cervical dilatation) is the absence of any progression of labor over a period of 2 h. The second stage (complete dilatation of the cervix until the onset of expulsive contractions) should not exceed 2 h.

14.1.3.2 Inadequate Progression of Labor Due to Maternal Factors (“the Passage”)

14.1.3.2.1 Cephalopelvic Disproportion

Failure of adequate progression of labor due to cephalopelvic disproportion with imminent fetal asphyxia is the most common reason to perform secondary cesarean section. Arrest is typically caused by a combination of a large infant, an abnormal birth mechanism, and a narrow maternal pelvis. Detectable abnormal narrowing with an absolute disproportion occurs in 0.5%–1% of all deliveries today (Fig. 14.1). The incidence of borderline pelvic findings in which the size of the child and the birth mechanism together decide whether spontaneous delivery will be possible is much higher (Table 14.1).

Other maternal factors that may prolong or arrest labor include cervical leiomyomas or scarring of the cervix after prior surgery (conization, cerclage). Rare causes that prevent fetal descent are pelvic tumors such as large ovarian cysts or a pelvic kidney.

14.1.3.3 Inadequate Progression of Labor Due to Fetal Factors (“the Passenger”)

An abnormal birth mechanism (abnormal fetal presentation and position) prevents adequate progression of labor just as often as maternal factors. Other fetal causes are macrosomia or fetal anomalies associated with macrohydrocephalus or an abnormally large circumference of the fetal abdomen or rump (pronounced ascites, sacrococcygeal teratoma).

14.1.3.4 Inadequate Progression of Labor Due to Inefficient Contraction (“the Powers”)

Weak uterine contractions as a cause of inadequate progression of labor are most amenable to treatment. Inefficiency may become manifest as hypoactive, hyperactive, or uncoordinated contractions and hypertonic motility. Both hypoactivity and hyperactivity may occur secondary to mechanical obstruction.

14.1.4 Interventional Management of Inadequate Progression of Labor

Of the three components involved in normal delivery (“Passages, Passenger, Powers”), only labor (“Powers”) is easily amenable to treatment.

Assistance in women with hypoactive and uncoordinated contractions is recommended if progression is delayed and cephalopelvic disproportion has been excluded as the cause. Oxytocin is the drug of first choice [5].

<table>
<thead>
<tr>
<th>Pelvic shape</th>
<th>Pelvic inlet</th>
<th>Pelvic outlet</th>
<th>Obstetric conjugate</th>
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<tbody>
<tr>
<td>Android</td>
<td>Normal</td>
<td>Shorter</td>
<td>Normal</td>
</tr>
<tr>
<td>Anthropoid</td>
<td>Shorter</td>
<td>Normal</td>
<td>Longer</td>
</tr>
<tr>
<td>Platypelloid</td>
<td>Longer</td>
<td>Normal</td>
<td>Shorter</td>
</tr>
</tbody>
</table>

Table 14.1. Features of different pelvic shapes in comparison with the gynecoid (normal) pelvis. An android pelvis is associated with a higher incidence of deep transverse arrest, an anthropoid pelvis with a higher incidence of dorsoposterior position, and a platypelloid pelvis with high longitudinal position. All three pelvic shapes are characterized by protracted labor.

Fig. 14.1a–c. Pelvic shapes from left to right: Normal pelvic shape and width (cranial view). Generally narrow pelvis (all pelvic parameters are shortened). Platypelloid pelvis with a markedly shorter obstetric conjugate.
In summary, arrested labor is often a multifactorial process resulting from the complex interaction of maternal pelvic size, size and presentation of the fetus, and labor activity. Effective therapeutic measures are only available for inadequate labor while no treatment is available for most other causes of arrested labor.

14.2 Clinical Methods of Pelvimetry

14.2.1 External Pelvimetry and Evaluation of Michaelis’ Rhomboid

The normal values for the external pelvic measures are 25–26 cm for the interspinous distance, 28–29 cm for the intercrest distance, 31–32 cm for the intertrochanteric distance, and 20 cm for the external conjugate. The internal conjugate is calculated as the external conjugate minus 9 cm.

Michaelis’s rhomboid is the rectangular area over the sacral bone formed by the dimple below the spinal processes of L3 to L4 (upper depression), the two posterior spines of the ilia (lateral depressions), and the groove at the distal end of the vertebral column (lower depression). The rhomboid is usually a square while its height increases considerably relative to its width in women with general narrowing of the pelvis. The lateral dimples are elevated in women with an android pelvis.

External pelvimetry will identify only pronounced deviations from the normal pelvic configuration that are rare in the European population.

14.2.2 Palpation of the Pelvis

The aim of palpation of the pelvis is to identify prominent bony structures that may obstruct labor. The examiner evaluates the angle of the pubic arch (>90°), the promontory (cannot be reached), the anterior surface of the sacrum (smooth), the coccyx (not prominent and elastic), and the ischial spines (not prominent).

Palpation has the disadvantage that the results cannot be standardized. The examination is extremely uncomfortable for the patient.

14.3 MR Pelvimetry

Magnetic resonance (MR) pelvimetry was introduced in 1985 by Stark et al. [6]. MRI offers the benefit of accurate measurements of bony pelvic structures without exposure to ionizing radiation. The technique further allows imaging of soft-tissue structures, including the fetus, and has therefore replaced X-ray and computed tomography (CT) pelvimetry to become the modality of choice for obstetric pelvimetry [6–8].

14.3.1 Safety Issues and Contraindications

Whereas prenatal X-ray exposure has been associated with an increased risk of childhood cancer [9, 10], numerous studies of MRI in pregnant women have not revealed any experimental or clinical evidence of fetal harm. Thus, MRI is considered safe for both the mother and the developing fetus [11, 12].

MR pelvimetry has become a well-established clinical indication during pregnancy. Nevertheless, there is a general consensus that MRI should be performed in the first trimester of pregnancy only if there are clear medical indications since rapid organogenesis takes place at this time and the fetus is thus most susceptible to any potentially hazardous external influences.

In our institution, MR pelvimetry is performed either postpartum – in women whose delivery was complicated by protracted labor and who plan to become pregnant again – or in the last trimester of pregnancy.

Due to the lower energy deposition in tissue, gradient-echo sequences are preferred to spin-echo sequences for MR pelvimetry in pregnant women [13–15].

A substantial contraindication to MRI in general is claustrophobia; other contraindications such as pacemakers and metallic splinters are comparatively rare in the obstetric population.

It should however be kept in mind that many women referred for MR pelvimetry are unfamiliar with MRI and may be intimidated by the sheer bulk of the equipment. Despite current evidence that MRI has no adverse fetal effects and of which the women should be informed before MRI, the noise and claustrophobia of an MR exam may well induce fear for
the fetus when imaging pregnant women and they should thus be especially well cared for during the exam by the staff of the MRI suite.

In women with physical effects like vena cava compression syndrome that may occur in late pregnancy, imaging can be performed in the lateral decubitus position.

14.3.2 MR Imaging Protocol

It has been shown in the literature that there are no significant differences in pelvimetric measurements between spin-echo and gradient-echo sequences [8, 14, 15]. Thus, gradient-echo sequences are favored over spin-echo sequences for MR pelvimetry due to the lower energy deposition already mentioned but also because of the shorter examination time [8, 13–15].

As mentioned above, MR pelvimetry is usually performed in the supine position. T1-weighted gradient-echo sequences of the maternal pelvis are acquired with the body coil in axial, sagittal, and oblique (in a plane through the symphysis and sacral promontory) orientation as shown in Fig. 14.2.

In our institution, MR pelvimetry is performed on a 1.5-Tesla Siemens Sonata MR scanner using a T1-weighted fast spoiled gradient-echo sequence (FSPGR) with the following parameters: repetition time (TR) 165 ms, echo time (TE) 10 ms, section thickness 6.0 mm, gap 20%, matrix 256×256, number of excitations (NEX) 2, anteroposterior phase-encoding direction. A large field of view (FOV), e.g. 380 mm, is used. Total examination time is only about 5–10 min.

14.3.3 Image Analysis

After the MR examination, pelvimetric measurements are performed on a workstation using the exterior surface of the appropriate bony cortex as the measuring point (Figs. 14.3, 14.4). The following pelvic distances are measured:

- The obstetric conjugate from the sacral promontory to the top inner cortex of the pubic bone at the symphysis is assessed in the midsagittal plane.
- The interspinous distance represents the narrowest distance between the ischial spine some millimeters below or in the plane through the fovea capitis. It is measured in the axial plane.
- The intertuberous distance is the widest distance between the ischial tuberosities and is also measured in the axial plane.
- The transverse diameter represents the largest transverse diameter in the oblique (through the promontory and the symphysis) axial plane [8, 16].

In our institution, all radiology suite technologists have been trained to select the appropriate images and measure the distances. Measurement is supervised by the radiologist writing the final report.

14.3.4 Reference Values for MR Pelvimetry

The groundwork in pelvimetry was laid using conventional radiography. Parameters were measured on lateral and anteroposterior views using various techniques to correct the distortion resulting from different distances from the film. These methods have since been superseded by cross-sectional imaging using computed tomography and, in particular, MRI. Nevertheless, values determined by plain radiography were still often used for guidance in the routine clinical setting. Yet studies comparing plain radiography and MR pelvimetry in the same population have described differences in some parameters, e.g. in intertuberous diameter [14, 17].

MR pelvimetric reference values in a large study population, stratified by delivery modality, have been established by our own group [8]. Results are shown in Table 14.2.

<table>
<thead>
<tr>
<th>Reference values ± SD (cm)</th>
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<tbody>
<tr>
<td>Obstetric conjugate</td>
</tr>
<tr>
<td>Sagittal outlet</td>
</tr>
<tr>
<td>Interspinous diameter</td>
</tr>
<tr>
<td>Intertuberous diameter</td>
</tr>
<tr>
<td>Transverse diameter</td>
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Fig. 14.2a–g. Imaging protocol for MR pelvimetry. A 34-year-old woman with a history of secondary cesarean section; retroverted uterus with susceptibility artifacts from surgical incision. 

**a** Axial localizing image for the midsagittal plane (Flash; TR 1110 ms, TE 3.37 ms, NEX 1, FOV 400 mm). 

**b** Sagittal T1-weighted gradient-echo sequence (Flash; TR 165 ms, TE 10 ms, NEX 2, FOV 380 mm): The obstetric conjugate and sagittal outlet are measured in the midsagittal plane. 

**c** Coronal localizing image for the interspinous and intertuberous distances (for parameters see a). 

**d** Axial T1-weighted gradient-echo sequence at the level of the fovea capitis (for parameters see a): The interspinous distance represents the narrowest distance between the ischial spines. 

**e** Axial T1-weighted gradient-echo sequence (for parameters see b): The intertuberous distance represents the widest distance between the ischial tuberosities. 

**f** Sagittal localizing image for the transverse diameter (for parameters see a). 

**g** Axial oblique T1-weighted gradient-echo sequence (for parameters see b): The transverse diameter represents the largest transverse distance.
Fig. 14.2d-g.
It was demonstrated that the pelvimetric parameters associated with the largest intra- and interobserver error and intraindividual variability are the intertuberous distance and sagittal outlet. Obstetric decision-makers should therefore treat them with caution [8].

A Cochrane Review lists four randomized controlled trials (RCT) on pelvimetry for fetal cephalic presentation [19]. All of these studies were performed using radiographic pelvimetry. The pelvimetry group had a higher rate of cesarean sections while fetal asphyxia and perinatal mortality tended to be lower but the difference did not reach significance (OR 0.61, CI 0.34–1.11 and OR 0.51, CI 0.18–1.42, respectively). Due to the small number of patients investigated and the poor quality of the studies quoted, the Cochrane Review concludes that the available evidence is not sufficient to prove a significant fetal benefit of radiographic pelvimetry in cephalic presentation.

One RCT has investigated pelvimetry in breech presentation [20]. In this study, Van Loon et al. [20] demonstrate that pelvimetry significantly reduces the rate of emergency cesarean sections. More recent studies in smaller patient populations show promising results using pelvimetry (mostly performed by MRI) in combination with sonographic weight measurement of the fetus [21–23] but these findings must be confirmed by RCTs.

**Fig. 14.3a-d. Pelvimetric diameters (drawings by G. Roth). a Obstetric conjugate and sagittal outlet. b Interspinous diameter. c Intertuberous diameter. d Transverse diameter (from [16])**

**14.4 Can Pelvimetry Improve Maternal and/or Fetal Outcome?**

Only few published studies have investigated the role of external pelvimetry. A prospective cohort study of primiparous African women showed that a combination of maternal height measurement and clinical external pelvimetry can identify a subgroup of patients with a high likelihood of cephalopelvic disproportion [18]. Comparable studies that present recent and robust data for western countries are not available.
Fig. 14.4a-d. MR pelvimetry (T1-weighted gradient-echo imaging) in a 29-year-old pregnant woman in the last trimester with small pelvic dimensions. Vaginal delivery was attempted but failed and secondary cesarean section became necessary. The mid-sagittal section shows (a) the obstetric conjugate (10.7 cm) and sagittal outlet (9.8 cm). Axial sections show (b) the interspinous distance (10.0 cm), measured at the level of the foveae of the femoral heads, and (c) the intertuberous distance (11.7 cm). The oblique section (d) shows the transverse diameter (11.8 cm).
14.5 Indications for Pelvimetry

14.5.1 Breech Presentation and Maternal Preference for Spontaneous Delivery

Breech presentation is a common obstetric abnormality occurring in 3%–5% of single pregnancies and 10%–15% of multiple pregnancies but there is no agreement about its most suitable obstetric management. The Canadian Medical Research Council (MRC) initiated an international randomized multicenter trial of planned vaginal birth versus planned cesarean section for breech presentation at term after an uncomplicated pregnancy [24]. The results show that planned cesarean section reduces the fetal complication rate while not affecting the maternal complication rate and the authors conclude that planned cesarean section is the optimal method of delivery for a fetus in breech presentation.

Following publication of these results, the rate of primary cesarean sections for breech presentations increased to up to 80%. Nevertheless, spontaneous delivery in breech presentation may be the preferred option of the mother. In such cases it is particularly important to exclude cephalopelvic disproportion.

14.5.2 After Cesarean Section Due to Arrest of Labor

The probability of secondary cesarean section after spontaneous onset of labor is about 10% in women without prior cesarean section as opposed to 40%–50% in women having had a cesarean section before. In order to reduce the rate of secondary cesarean section, we perform postpartum pelvimetry and recommend primary cesarean section for future pregnancies in those women who are found to have a narrow pelvis because they are at high risk of renewed arrest of labor.

14.5.3 Clinically Conspicuous Abnormalities of Pelvic Shape and Status Post Pelvic Fracture

Only 0.5%–1% of all pregnant women have such obvious pelvic anomalies that absolute cephalopelvic disproportion is highly likely. The risk of absolute disproportion is especially high in women after pelvic fracture or with diseases that alter pelvic shape (osteochondroplasia, osteomalacia). In these cases, pelvimetry is mandatory.

References

try: effect of birthing position on pelvic bony dimensions. AJR Am J Roentgenol 179:1063-1067