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NO. 95173-0

SUPREME COURT OF THE STATE OF WASHINGTON

L.M., a minor, by and through his Guardian ad Litem
WILLIAM L.E. DUSSAULT,

Plaintiff/Petitioner

vs.

LAURA HAMILTON, individually and her
marital community; LAURA HAMILTON LICENSED
MIDWIFE, a Washington business,

Defendant/Respondent.

SUPPLEMENTAL BRIEF OF PETITIONER

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A. IDENTITY OF PETITIONER

Petitioner, Levi Zane Myhre, by and through his Guardian ad Litem, William L.E. Dussault, respectfully submits the following supplemental brief.

B. SUMMARY OF ISSUES

This case arises from the nearly complete rupture and/or avulsion of Levi's brachial plexus nerves at all five levels. Levi has no use of his arm and shoulder, and he can move only the thumb and index finger of his hand.

The issues appealed here involve the limits of expert testimony. First, the issues appealed in this case test what it means that the underlying scientific theory and the techniques, experiments, or studies utilizing the theory must be generally accepted in the relevant scientific community and capable of producing reliable results. *Lakey v. Puget Sound Energy, Inc.*, 176 Wn.2d 909, 918, 296 P.3d 860 (2013). Second, the issues appealed in this case require the Court to revisit the admission of biomechanical engineering testimony that claims to estimate the forces acting upon the body and whether those forces are sufficient to injure the person. The scientific foundation for the evidence, its relevance, and the qualifications of the expert are all at issue here when a biomechanical engineer from the orthopedics department purports to testify about matters which his own sources say are unknown to science.

The trial court acts as gatekeeper when determining the admissibility of evidence. Unfortunately, when the gate is wide open, the principles underlying the *Frye* rule are not met, causing confusion and speculation among the jurors, when they hear expert testimony that is not generally accepted in the scientific community. Unfortunately, the jury is confused, and even, misled, when an expert biomechanical engineer claims the ability to calculate the forces acting on a baby during birth and claims that those forces alone can cause the nerve injury suffered, even though his own sources deny that this can be done. It is particularly misleading when the expert makes no attempt to apply the so-called science to the facts of this case.

The petitioner respectfully asks the Court to reverse the Court of Appeals and rule that the "natural forces of labor" (NFOL) theory and the methods used to support it are not generally accepted in the scientific community. Further, rule that the trial court abused its discretion when it admitted the testimony of the biomechanical engineer.

C. III. STATEMENT OF THE CASE

Several points on the record here should be emphasized.

First, the petitioner appeals the trial court's decisions to allow the NFOL defense and the testimony of Allan Tencer, the biomechanical engineer. Consequently, the evidence before the trial court when the

decisions were made should be scrutinized more than the trial testimony, although the trial testimony does nothing to support the respondent's claim that the NFOL defense is based upon science that is generally accepted in the scientific community. In fact, Tencer's trial testimony veers drastically from the declaration ruled on by the trial court, and he offered an opinion at trial that was misleading. 10/27 RP 17:19 – 19:5.

Second, it is a complete misstatement of the record that petitioner's experts acknowledged that the natural forces of labor alone can cause avulsion and rupture injuries of the brachial plexus nerves, as respondent claims. Petitioner's expert, Dr. Mandell, testified that there is no reference "in the history of medicine" of a brachial plexus nerve avulsion caused by the natural forces of labor. 10/21 RP 117:18-21; 118:19-22. Dr. Mandell also explained why no study demonstrates that traction is required to cause avulsion: "Well, that would be criminal to cause avulsion just to prove a medical point." 10/21 RP 90:20-24.

Petitioner's pediatric neurologist, Dr. Glass, acknowledged that the natural forces of labor can contribute to "some plexus" injuries, but "the real question is do they produce plexus injuries that are of a severity such as this with multiple nerve root avulsions, multiple ruptures, and limb that is almost completely without function as a result of that injury. We don't know that. If it does happen, it's exceedingly rare and yet there's no case

report, not one, that describes this type of injury following natural forces alone." 10/22 RP 5-13. He further testified that "there is no link and no relationship between the natural forces of labor only and avulsion injuries." 10/22 RP 115:8-10. Of the proponents that NFOL can cause all brachial plexus injuries, Dr. Glass testified:

> [T]here are some who are fervent believers that natural forces are responsible for most, if not all, plexus injuries. It's just, frankly, foolish. There's no data to support that and it's wrong.
> There are a number of papers address [sic] the natural forces and their risk of producing plexus injuries. And the issue is not so much the number of papers but rather the scientific rigor with which they are written or prepared. That's what puts them in question and puts the whole causation issue very, very uncertain in terms of its contribution.
> 10/22 RP 119:1-11.

Even respondent's expert, Dr. Sanford, testified in her deposition that the medical literature does not describe an avulsion injury caused by the natural forces of labor alone: "I don't have anything in the literature that specifically – that I recall talks about [a]vulsion versus anything stretching . . . the medical literature does not really specifically state one way or another . . . " CP 1468. Dr. Sanford was unaware of any medical literature that attribute an avulsion injury from the natural forces of labor. CP 1469.

Third, it is also a misstatement that Tencer did not testify as to causation. He not only testified as to causation, he gave a completely

erroneous explanation of the injury that Levi suffered. 10/27 RP 22:6-9. He testified: ". . . your nerves are always stretching so they're designed to stretch. But what they're not really designed to take is much compression. So you have greater compressive forces and they're more vulnerable to compression." 10/27 RP 18:21-25.

It is undisputed that Levi suffered a stretch injury to his brachial plexus. 10/28 (DeMott) 24:6-25; 10/21 (Mandel) 63:12-15.

D. ARGUMENT

1. Tencer's testimony should have been excluded, because he is unqualified to give expert opinions on labor and childbirth.

Petitioner has argued consistently that Tencer is not qualified as an expert in injuries from childbirth. He never before testified as an expert in a labor and delivery case. 10/27 RP 9:14-16. He has testified mostly in motor vehicle accident cases, some slip and fall cases, and some "fisheries-type injuries." 10/27 RP 9:8-10.

He claims that he is equally as qualified as biomechanical engineer, Michele Grimm, whose articles he read. CP 2373-2374. However, Dr. Grimm has studied the natural forces of labor and published widely on the subject. Tencer has had no professional connection with labor and childbirth until he did nothing more than read Dr. Grimm's articles. This does not make him an expert in her field. A psychiatrist and a brain surgeon

will have the same M.D. degree, but no court would admit a psychiatrist's expert opinion about whether the brain surgeon fell below the standard of care.

That Tencer is unqualified to testify about Levi's brachial plexus injury is demonstrated by his complete lack of understanding of Levi's injury. Tencer's testimony suggesting that Levi suffered a compression injury to his brachial plexus proves that he either has no idea what he is talking about, or he intended to mislead the jury that Levi suffered a compression injury to his nerves. 10/27 RP 18:21-25. Either way, he should not have been allowed to testify.

2. Tencer's testimony should have been excluded, because he rendered opinions on matters that are not known to science and cannot be known.

Tencer has been precluded from testifying in several Washington courts. *Stedman v. Cooper*, 172 Wn. App. 9, 17-21, 292 P. 3d 764 (2012). In reviewing a trail court's exclusion of expert testimony under the rules of evidence, the standard is abuse of discretion. A court does not abuse its discretion only when it follows the analytical framework of the Rules of Evidence. *Johnston-Forbes v. Masunaga*, 181 Wn. 2d 346, 354, 333 P.3d 388 (2014). To be admissible, expert witness testimony must be relevant and helpful to the trier of fact. *Anderson v. Akzo Nobel Coatings, Inc.*, 172 Wn.2d 593, 606, 260 P.3d 857 (2011). Conclusory or speculative expert

opinions lacking an adequate foundation will not be admitted. *Miller v. Likins*, 109 Wn. App. 140, 148, 34 P.3d 835 (2001). When ruling on somewhat speculative testimony, the court should keep in mind the danger that the jury may be overly impressed with a witness possessing the aura of an expert. *Id.* A trial court may exclude expert testimony when it is likely to create unreasonable inferences and confuse and mislead the jury. *Gilmore v. Jefferson County Pub. Transp. Benefit Area*, 190 Wn.2d 483, 498, 415 P.3d 212 (2018).

In the present case, Tencer's testimony lacked foundation and was speculative, because Tencer testified to measurements of forces that are not known to science. Further, his testimony was irrelevant, because he made no attempt to base his opinions on the facts of this case. *Miller*, 109 Wn. App at 149-150. Rather than testifying to scientific theories and methods that are generally accepted in the scientific community, the assertions made by Tencer in his declaration and at trial are generally rejected by science. The trial court erred when it allowed Tencer to testify.

Petitioner argued before the trial court that Tencer's testimony would be misleading to the jury, both as to the measured forces acting upon the baby during labor and delivery, as well as the amount of force required to rupture or avulse the brachial plexus of a newborn. The forces used by Hamilton were not measured or estimated, and more importantly, the force

required to rupture or avulse the nerve of a newborn is not known and cannot be known.

Tencer testified in his declaration on Hamilton's motion to allow his testimony at trial that it is well-established how much force is placed on an infant by endogenous or exogenous sources. He testified that in studies, exogenous forces ranged from 100 N to up to 250 N, but that most clinicians applied less than 150 N during delivery. CP 3182. Tencer's testimony that "most clinicians" applied less than 150 N was based on one study of only 113 simulated deliveries. The testimony covers up the other findings in the study, particularly that forces as high as 254 N were reported, and 28% of the clinicians in the study used force in excess of 150 N. CP 3182; 3195. There was nothing in Tencer's testimony to suggest that Hamilton did not use excess force or that force less than 150 N is safe. His testimony was crafted to cause the jury to speculate or assume that Hamilton applied a safe amount of force.

This study and others were summarized in the article by Dr. Grimm that Tencer relied upon. In the article, Dr. Grimm cautioned that the studies "do not directly match the clinical environment." The studies give only "insight into clinician behavior at delivery." CP 3182; 3195. Thus, Tencer's testimony about the forces reported in the study of 113 deliveries is irrelevant and misleading to the issues in this case. The Court should

consider whether the studies were conducted under circumstances substantially similar to those existing at the time Levi was born. *Stedman*, 172 Wn. App. at 12-13. In this case, the trial court knew from the medical literature that the studies do not directly match the clinical environment and give only insight in to clinician behavior at delivery.

Tencer testified in his declaration and at trial that the endogenous forces are always more than the exogenous forces. CP 3183; 2375; 10/27 RP 18:10-13. Again, Tencer relied upon Dr. Grimm's work, in which she is more guarded in her conclusions. She wrote that her mathematical model could only "crudely examine this complex issue of forces and pressures." CP 3183; 3200. A "crude" examination hardly rises to the level of established science.

This testimony purporting to establish the forces acting on the baby from maternal forces and clinician forces is largely irrelevant, because it is unknown how much force is required to rupture or avulse the brachial plexus of a newborn human. Tencer testified in his declaration that the "force required to fracture a clavicle or other bone is greater than the force required to rupture a nerve or avulse a nerve root from the spinal cord." CP 3183; 2376. However, there are two reasons this statement is misleading and irrelevant.

First, the statement is irrelevant, because the force required to fracture a clavicle is compressive force, but the force required to cause the rupture/avulsion injuries suffered by Levi is a pulling force. Second, and more importantly, Dr. Grimm states that "an estimate of the force needed to cause a nerve rupture cannot be directly established." CP 3183; 2436. She also states: "The nerve tissue properties of the newborn brachial plexus have not been adequately studied to establish thresholds for damage based on either applied force or resulting stretch." CP 3184; 2436. "Additionally, there are no data to quantify the threshold pressures needed to induce traction versus compression related nerve injury." CP 3184; 3204. Most importantly, there is no permissible or safe amount of traction force that can be applied during delivery to deliver the shoulders. CP 3202; 2436. Tencer's claims that he can testify to what, according to the scientific community, is not known and cannot be known should not have been given any weight by the trial court, and Tencer's testimony should have been excluded.

In his declaration, Tencer referenced his own research, which he did not identify or discuss at any length so that the trial court could determine whether the research was relevant to Levi's case. CP 3184. Instead of requiring Tencer to produce the research, the trial court merely allowed Tencer to testify without ascertaining whether the research had any

relationship to the issues in this case. As it turned out, Tencer testified that his research was on adult, cadaver spines, which are not comparable to newborn nerves. CP 3202; 10/27 RP 25:20-24. The trial court abused its discretion in admitting Tencer's testimony without examining the validity of his claims.

At trial, Tencer's testimony included opinion testimony that the trial court had excluded, as well as a completely erroneous description of the mechanism of Levi's injury and testimony regarding adult cadaver studies of the dura. Tencer testified about causation, in spite of Hamilton's assurance to the trial court. 10/27 RP 22:6-9. Even though the trial court instructed Hamilton's counsel not to ask about causation, the question was asked anyway, and the bell could not be "unrung."

The trial court erred in allowing Tencer to testify, and as a result, his testimony before the jury was irrelevant and misleading. The testimony misled the jury into thinking there is a safe amount of force to apply when delivering a baby and that Levi's injury could have been caused by the pressure of shoulder pressing upon the pubic bone. More disturbing is that Tencer's testimony misled the jury into thinking there was credible science behind his opinions, which there is not. The Petitioner respectfully asks the Court to rule that the trial court abused its discretion when it admitted Tencer's testimony.

3. The "natural forces of labor" defense does not meet the *Frye* standard, because the theory and the methods supporting it are not generally accepted in the scientific community.

The trial court erred when it allowed testimony that Levi's avulsion/rupture injuries could have been caused by the natural forces of labor. This defense does not meet the *Frye* standard, which is the law in Washington, that scientific theory or method must be generally accepted in the scientific community. *Frye v. U.S.*, 293 F. 1013 (App. D.C. 1923; *Anderson v. Akzo Nobel Coatings, Inc.*, 172 Wn.2d 593 (2011); *Moore v. Harley-Davidson Motor Co. Group, Inc.*, 158 Wn. App. 407, 241 P.3d 808 (2010). ER 702. Expert testimony is admissible under *Frye* where "(1) the scientific theory or principle upon which the evidence is based has gained general acceptance in the relevant scientific community of which it is a part; and (2) there are generally accepted methods of applying the theory or principle in a manner capable of producing reliable results." *Lake Chelan Shores Homeowners Ass'n v. St. Paul Fire & Marine Ins. Co.,* 176 Wn. App. 168, 175 (2013), *review denied*, 179 Wn.2d 1019 (2014). Evidence is inadmissible under *Frye* if, as here, there is a significant dispute among qualified scientists in the relevant scientific community. *Anderson*, 172 Wn.2d at 603. A court's decision to admit scientific evidence under the *Frye* standard is reviewed de novo. *Lakey v. Puget Sound Energy, Inc.*, 176 Wn.2d 909, 919, 296 P.3d 838 (2013).

Further, expert witnesses may not engage in conjecture or speculation. ER 702. The trial court must find that there is an adequate foundation so that opinion is not speculation, conjecture, or misleading. *Johnston-Forbes v. Matsunaga*, 181 Wn.2d at 357. The NFOL defense satisfies neither standard, and the trial court erred in allowing testimony asserting this theory.

Petitioner, in his petition for review, detailed the lack of general acceptance that is acknowledged in nearly every article on NFOL that was submitted to the trial court. Even defense expert, Dr. Sanford, testified to lack of consensus and lack of generally accepted scientific methods that can be applied to this theory to produce reliable results. CP 1467-1469. The litany of doubts expressed by the authors of these articles is set forth in detail in the petition for review and is not repeated here.

Two things, however, should be emphasized. First, the acknowledged bias of the authors of these articles should, by itself, be sufficient to cast doubt on this theory as being generally accepted or based upon methods that are generally accepted. CP 2009; 2021. Second, the very studies relied upon by Hamilton's experts show that, shoulder dysocias attended by a midwife, nurse, corpsman, or osteopath are at 3-to-4-fold increased risk of neonatal brachial plexus injury. CP 2018. The physiology of women and babies do not change from provider to provider.

Consequently, the only explanation for this result is that the practitioner applied too much traction during delivery. Hamilton was a midwife, and yet, the trial court allowed expert testimony that the NFOL, caused Levi's near-complete loss of use of his arm, and not traction used by the midwife. That this study result was completely ignored and left unexplained confirms that the NFOL literature is biased and not reliable.

Without meaningful results and reliable methods, the opinions by Hamilton's experts were speculative and merely conjecture. ER 702. None of the medical literature, not a single case report, reveals that the nearly total ripping away of Levi's brachial plexus nerve could have been caused by the natural forces of labor alone. The trial court should have excluded this evidence, and the Court should so rule.

The Court should reverse the Court of Appeals and rule that the NFOL defense is not generally accepted in the scientific community and does employ methods that produce reliable results.

4. The Court should remand for a *Frye* hearing.

If the Court declines to rule that the NFOL defense does not meet the *Frye* standard, and although the court in *Johnston-Forbes,* declined to remand for a *Frye* hearing, the Court should remand in this case. *Johnston-Forbes v. Matsunana,* 181 Wn.2d at 356. Petitioner did not request a *Frye* hearing in the trial court, after the court changed its ruling on

reconsideration on October 12, 2015, just days before the start of trial. However, Petitioner argued since August 19, 2015, that the NFOL defense does not meet the *Frye* standard. CP 1475.

In *Johnston-Forbes,* the petitioner never challenged the expert testimony on the basis that it was not generally accepted in the scientific community. *Id.* In the present case, the Petitioner has made this argument during the entire litigation. Because this issue has been before the trial court and the Court of Appeals, Petitioner respectfully asks the Court to determine that a *Frye* hearing can be had under these circumstances.

5. The Court should consider additional medical literature, as in *In re Det. of Pettis*.

The Court of Appeals has considered medical literature that was not before the trial court in determining whether expert testimony complies with the *Frye* standard. *In re Det. of Pettis,* 188 Wn. App. 198, 208-209, 352 P.3d 841 (2015). Petitioner respectfully requests the Court consider a peer-reviewed international journal. In 2016, a published article concluded that "[t]he weight of the available information suggests, however, that inopportune medical intervention is probably a factor in most (brachial plexus) injuries." Meghan G. Hill & Wayne R. Cohen, *Shoulder Dystocia: Prediction and Management,* Womens Health (Lond)., 2016 Mar; 12(2): 251-261, attached hereto as Petitioner's Appendix 1, page 001.

Another peer-reviewed journal affirmed that the science showing that brachial plexus injuries are caused by excessive traction by the delivering provider is still favored by obstetricians outside the US and by nearly all neurologists. Iffy, *Prevention of shoulder dystocia related birth injuries: myths and facts,* World Journal of Obstetrics and Gynocology, Nov. 10, 2014; 3(4): 148-161. This article also discussed that shoulder dystocia and associated injury has increased since the 1970's with the introduction of active management of delivery. Attached hereto as Petitioner's Appendix 2, pages 006; 001.

These articles show a significant difference of opinion between neurologists and obstetricians, as well as among obstetricians inside and outside the United States. The Court should rule that the NFOL defense does not meet the *Frye* standard and that it is speculative and misleading to the jury under ER 702. In the alternative, the Petitioner asks the Court for an extension of the law to remand this case for a *Frye* hearing.

E. CONCLUSION

Washington law and the Rules of Evidence allow for expert testimony, only when the theory and methods are generally accepted within the scientific community and the testimony meets the requirements of ER 702. Courts fail in their gate-keeping function, when everything comes in, regardless of the science. In this case, every article cited by Hamilton's

experts qualifies its methodology or conclusions, meaning that the theory has fatal flaws in the methodology or supporting facts. Consequently, the trial court erred in allowing the testimony, and Levi asks that the Court reverse and remand.

DATED THIS 28TH day of September, 2018.

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The undersigned certifies under the penalty of perjury under the laws of the State of Washington that on the below date, I caused to be served upon the following individuals via the methods indicated:

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Shoulder Dystocia: Prediction and Management

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Abstract

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Shoulder dystocia is a complication of vaginal delivery and the primary factor associated with brachial plexus injury. In this review, we discuss the risk factors for shoulder dystocia and propose a framework for the prediction and prevention of the complication. A recommended approach to management when shoulder dystocia occurs is outlined, with review of the maneuvers used to relieve the obstruction with minimal risk of fetal and maternal injury.

Keywords: birth trauma, brachial plexus injury, diabetes, Erb palsy, macrosomia, shoulder dystocia

Shoulder dystocia, a complication of vaginal delivery in which the fetal shoulders fail to deliver spontaneously after the head emerges, is uncommon but potentially treacherous. Its precise incidence is difficult to ascertain, owing to the different definitions used in the literature and uncertainty about how often its occurrence is documented in medical records. Estimates range between 0.15 and 2.0% [1–3]. Although most cases of shoulder dystocia can be relieved without permanent sequelae for the neonate, this is not always the case [4,5]. Complications include various degrees of brachial plexus injury (BPI) and, less commonly, asphyxial or traumatic central nervous system damage and long bone fractures [6]. Maternal adversity in the form of lacerations, hemorrhage and psychological stress occurs as well [7]. BPI occurs in about 1–20% of shoulder dystocia cases [1–2,6,8]. It is often a transient neuropraxis and recovers fully in hours to months; it is permanent in about 3–10% of cases [6,9], probably the result of avulsion of nerve tissue. The likelihood of intact survival after shoulder dystocia depends heavily on the skill with which it is managed; preemptive cesarean delivery of babies at high risk would be ideal, but the identification of such cases can be challenging.

Almost all BPIs associated with shoulder dystocia are Erb palsies, and result from overstretching of the C5–6 nerve roots during parturition, particularly in the presence of difficult shoulder delivery. There is enough evidence that BPI can occur in the absence of shoulder dystocia to conclude that not every injury is the consequence of excessive force applied by the obstetrician or midwife [10,11]. Moreover, it seems equally clear that BPI can occur in association with shoulder dystocia even when the complication has been managed optimally. The weight of the available information suggests, however, that inopportune medical intervention is probably a factor in most injuries.

Universal cesarean delivery would eliminate almost all cases of shoulder injury; but this approach is impractical, and would have an unfavorable risk/benefit balance. In this regard it should be noted that the incidence of shoulder dystocia seems to have increased in some places [12], even as the cesarean rate has risen substantially over recent decades. The incidence of Erb palsy, however, may have been be more stable [13,14], although a study from Sweden showed a dramatic increase between 1980 and 1994 [15]. Whether these differences in incidence and trend relate to ascertainment bias, variations in definitions and reporting or are the consequence of improved obstetric practice is unknown. Certainly, in order for the clinician to minimize the incidence of BPI or other adverse sequelae of shoulder dystocia she or he must be thoroughly familiar with existing risk factors, incorporate them into a decision matrix for each patient, offer cesarean delivery when risks are very high and be prepared to deal expertly with shoulder dystocia if it occurs.

Risk factors

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To optimize outcomes we should aim to avoid injury from shoulder dystocia and, when possible, avert its occurrence. One step toward avoidance is to identify the patient at increased risk for shoulder dystocia and BPI.

There are a number of maternal and fetal characteristics associated with the development of shoulder dystocia and BPI, but many cases develop without recognized antecedent risk factors [16]. The ability to predict the occurrence in an individual delivery is limited, but not unachievable (see below), and the prevailing notion that shoulder dystocia is always an unexpected complication has done little to advance our understanding of how it might be prevented [17,18]. Several algorithms have been suggested to predict and thereby prevent shoulder dystocia based on identifiable predisposing factors [19–23]. Risk factors for shoulder dystocia and BPI can be usefully categorized into those identifiable in the patient's history, and those that arise or are identified during prenatal care or labor (Box 1).

Box 1.

Major risk factors for shoulder dystocia and Erb palsy.

Box 1. Major risk factors for shoulder dystocia and Erb palsy.

History

- History of shoulder dystocia or baby with BPI
- Maternal diabetes
- Maternal obesity

Antepartum factors

- Macrosomia (risk increases as fetal weight increases)
- Gestational diabetes
- Excessive weight gain

Intrapartum factors

- Clinical pelvimetry and estimated fetal weight concerning for CPD
- Protracted active phase dilatation
- Arrest of dilatation
- Prolonged deceleration phase
- Failed, protracted or arrested descent
- Long second stage
- Precipitate second stage
- Instrumental delivery

BPI: Brachial plexus injury; CPD: Cephalopelvic disproportion.

Open in a separate window

History

- History of shoulder dystocia or baby with BPI
- Maternal diabetes
- Maternal obesity

Antepartum factors

- Macrosomia (risk increases as fetal weight increases)
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- Precipitate second stage
- Instrumental delivery

BPI: Brachial plexus injury; CPD: Cephalopelvic disproportion.

Obstetric history

Go to:

A woman with a prior pregnancy complicated by shoulder dystocia or BPI, neonatal macrosomia or diabetes mellitus is at increased risk for difficult shoulder delivery [24,25]. A previous shoulder dystocia increases the risk of recurrence several fold; up to 10–20% of patients have the complication with a subsequent birth [24–26], often with a higher incidence of associated BPI than the primary case [24]. These observations make it reasonable to offer cesarean delivery to patients with a history of shoulder dystocia in a previous pregnancy, particularly if there are other associated risk factors present.

Having had a macrosomic infant previously also increases the risk of shoulder dystocia [27]. It is uncertain whether a family history of shoulder dystocia in a sister or mother predisposes the patient to the complication or if differences in racial background or body type of the father of the pregnancy plays a role. In general, fetal growth is more dependent on maternal than paternal body composition and stature, although paternal stature contributes [28,29].

Other factors that some studies have associated with elevated rates of fetal macrosomia (and presumably shoulder dystocia) include high maternal birth weight, short stature, preexisting obesity, diabetes, excessive weight gain in pregnancy and advanced maternal age [30–33].

Prenatal care

Go to:

A number of further risk factors are identifiable during the course of prenatal care. Some of these are potentially modifiable, but most are not. Prominent among these are maternal obesity [30,34], excessive weight gain [27,35], various degrees of glucose intolerance [36,37] and multiparity [30]. Ideally, maternal obesity should be addressed before pregnancy. Substantial weight loss is not prudent during gestation because it may predispose to small for gestational age infants, especially in women with relatively mild obesity [38]. Moderation of caloric intake and careful attention to weight gain during pregnancy does reduce the risk of macrosomia in women with class II and III obesity [38].

Maternal diabetes mellitus has long been recognized as a strong risk factor for shoulder dystocia [39–41]. In addition to predisposing to macrosomia [42], diabetes, especially if glycemic control is poor, confers differences in body proportions that probably explain why, at any given birth weight, the fetus of a diabetic mother is more likely to experience shoulder delivery obstruction than one of a nondiabetic [41,43–44]. The fetus of a diabetic is prone to central growth and adiposity, with the trunk relatively large compared with the head [37,45]. In fact, this disproportionate growth affects large babies of nondiabetics, and helps explain the high incidence of shoulder dystocia among them [45,46].

Glucose tolerance exists on a continuum, and it is therefore not surprising that the incidence of neonatal macrosomia, shoulder dystocia and BPI is increased among women who have a positive 50 g glucose

challenge test followed by a negative glucose tolerance test, particularly if the latter has one abnormal value [36,37].

Intrapartum observations

Go to:

Careful evaluation of a parturient can reveal risk factors not previously recognized. Clinical or ultrasonographic estimation of fetal weight is valuable. Indeed, fetal macrosomia (variously defined) is the strongest risk factor for shoulder dystocia and BPI in both diabetic and nondiabetic pregnancies (Box 1) [47,48].

Estimation of fetal weight can, however, be challenging, especially in the large fetus, for which measurement errors can be substantial. Even ultrasonography does not always provide highly accurate fetal weight estimates [49,50]. In part for that reason, recommendation for cesarean delivery based solely on a high estimated fetal weight is not likely to be cost effective and would result in an excessive number of unnecessary cesareans [51–53]. Moreover, approximately half of shoulder dystocia events occur in fetuses weighing <4000 g [3,52], so simply using a weight cutoff to preclude a trial of labor will not prevent many cases [50,52]. The American Congress of Obstetricians and Gynecologists has suggested consideration of cesarean section to prevent a shoulder dystocia at an estimated fetal weight of 4500 g in a diabetic and 5000 g in a nondiabetic patient, although several hundred cesareans would probably required for prevention of each BPI using such weight criteria [51].

Induction of labor in cases of suspected fetal macrosomia does not decrease the incidence of shoulder dystocia, except perhaps in some diabetics [54–56]. Likewise, although a male fetus is more likely to have shoulder dystocia than a female [57], male fetal sex is not a sufficiently compelling reason to recommend induction of labor or cesarean to prevent shoulder dystocia.

Thorough clinical cephalopelvimetry can be especially helpful to the clinician in assessing risk, because certain pelvic features predispose to difficult shoulder delivery. The presence of a narrow anteroposterior outlet diameter (common in a pelvis with android or platypelloid features), or a long and steeply inclined pubic symphysis (seen primarily in an anthropoid pelvis), should alert the clinician to an increased risk, especially if other predisposing factors exist. Shoulder dystocia can even occur in a gynecoid pelvis if it is unusually small or descent is precipitate.

As labor progresses, certain abnormalities of dilatation and descent signal further risk, probably because of their association with fetal macrosomia or fetopelvic disproportion. In at least half of BPI cases a preceding dysfunctional labor pattern can be identified [37]. Arrest and protraction disorders of the active phase and second stage probably predispose, as does (seemingly paradoxically) precipitate descent [58]. But one abnormality of the first stage, a prolonged deceleration phase, has a particularly strong association with shoulder dystocia and neonatal BPI [27,30,59]. This abnormality, which occurs when final retraction of the cervix around the fetal head is delayed because fetal descent cannot be timely initiated, is an important bellwether for second stage abnormalities and shoulder dystocia. When a prolonged deceleration phase is combined with a second stage longer than 2 h the odds of BPI increase 20-fold [20].

Decisions about assisted vaginal delivery in the setting of a prolonged second stage in a patient with a suspected macrosomic fetus should be informed by the fact that the use of forceps or vacuum extractor substantially increases the risk of shoulder dystocia [60]. This is especially true if the delivery is done from the midpelvis, but applies as well to all instrumental deliveries [2,61–62]. Moreover, the shoulder dystocia associated with these deliveries is more likely to require complex maneuvers and result in fetal injury [61].

Prediction

Go to:

It is often assumed that shoulder dystocia is an unpredictable and, therefore, unpreventable complication [17,63] but this fatalism is unwarranted. Although predicting with certainty that shoulder dystocia or BPI will occur in a particular case is rarely possible, our ability to identify cases in which shoulder problems are likely is improving and can help guide clinical decisions.

Three kinds of systematic attempts to identify cases at high risk have been promulgated. One uses late pregnancy or intrapartum sonographic measurements of body weight and dimensions, an attempt to identify the fetus with macrosomia or a disproportionately large trunk or bisacromial diameter. Empiric risk scores have also been used, based on the assumption that there might be a direct relationship between the number and type of risk factors and likelihood of shoulder complications. Finally, multivariate statistical techniques can assess risk factors based on their strength and interaction in a population so that risk can be assessed for an individual patient [20–21,64]. These approaches have yielded mixed results.

Ultrasonography has not proved very helpful in identifying candidates for preemptive cesarean delivery. Shoulder dystocia and BPI are strongly associated with large fetal weight [65] but, although using a weight threshold for preventive cesarean will forestall many cases, the trade-off in higher economic cost and in maternal and neonatal morbidity is substantial [65–68]. A more focused approach that relies on identifying the fetus with disproportionate trunk or shoulder girdle growth seems more promising, but the predictive values and false positive rates are not encouraging [69]. Gerber *et al.*, for example, found that for an abdominal/head circumference ratio above 1.05 the sensitivity and specificity for the prediction of shoulder dystocia were 46 and 75%, respectively, with a positive predictive value of only 5.7% [70]. Similar results were obtained by other investigators [71].

Risk factors, as discussed above, are characteristics or events shown to occur with a significantly higher frequency in association with the outcome under study. But a distinction must be made between risk factors and predictive factors. Many strong risk factors for an outcome are poor predictors of it, particularly if they are prevalent in the population. For example, maternal obesity has a strong association with shoulder dystocia and BPI; but the presence of obesity in an individual is a poor predictor of BPI because obesity is common, and only a small proportion of obese parturients have shoulder dystocia or BPI. Further complicating this issue is that many of the strong risk factors for shoulder dystocia are not mutually exclusive, and their interactions are not well understood. For example, gestational diabetes mellitus, obesity, fetal macrosomia, excessive weight gain and dysfunctional labor frequently coexist, and whether their individual influences on risk overlap, are additive, or multiplicative may be difficult to discern statistically. Moreover, the independent effects of variables may vary among patients according to the complex clinical situation in which they occur. That may be why empiric risk scoring systems have not been fruitful [22,23].

Multivariate analytic techniques, which can consider the interaction of risk variables associated with shoulder dystocia or injury, hold the most promise for prediction [20–21,64]. One study created an Erb palsy risk score from a series of 45 cases. Applied to a theoretical population, the risk scoring system would prevent 36% of BPI cases and result in 14 (in retrospect, unnecessary) cesarean deliveries for each BPI averted [20].

To optimize the value of these multivariate predictive systems they must be unique to the population in which they are used because the influence of demographic variables will depend on their prevalence in the population. Even the baseline prevalence of shoulder dystocia and BPI will affect the value of these systems. In addition, only variables the practitioner can discern and act upon before delivery should be used. Thus, in a decision matrix aimed to reduce the incidence of BPI, variables like birth weight (which cannot be known accurately before delivery) or the presence of shoulder dystocia (which, once present, precludes preemptive cesarean) should not be incorporated as variables. Unfortunately, variables that could be valuable in a risk scoring system, such as pelvic architectural features and

details of obstetric history, are often not recorded, or are not assessed with sufficient clarity to be of value.

Given the current state of our knowledge, and the fact that multivariate risk scoring systems are not yet suitable for general use, what approach should the practitioner take to minimize the incidence of BPI without doing an excessive number of cesarean deliveries? A practical approach is to consider the presence of risk factors in the three categories described above (historical, prenatal and intrapartum). The presence of strong risk factors in two or three categories should prompt strong consideration of cesarean delivery. It is necessary to consider that the adverse influence of a risk factor is affected by its severity. Poorly controlled diabetes presents greater hazard than a case with euglycemia; an estimated fetal weight of 5 kg is more concerning than one of 4 kg; a prior shoulder dystocia that resulted in permanent BPI is of greater importance than one that resolved without injury. Moreover, risk assessment is a serial process, and as new problems are identified during the course of care, especially during labor, plans can be altered accordingly. For example, the development of a prolonged deceleration phase in a woman with other risk factors may well be sufficient to tip the scales in favor of cesarean section.

Clinical management

Go to:

When shoulder dystocia occurs there is an understandable urgency perceived by everyone in the room, not least the patient, who is generally quick to react with anxiety to fears expressed by the staff or to chaotic behavior. Although the situation needs to be addressed promptly and efficiently, hasty management can do serious damage. Deliberate and logical steps should be taken, and, assuming that fetal oxygenation was normal at the onset of the dystocia, taking several minutes to deliver the fetus rarely causes significant morbidity. To ensure optimal outcome the primary provider and the rest of the team must institute a coordinated prescriptive plan of action. There is some evidence that staff training approaches including drills, checklists and debriefings after shoulder dystocia cases can be helpful. They improve documentation and result in superior outcomes [72,73]. It is important that all staff are included in these training exercises so that everyone understands her or his role when this emergency occurs [34,73–75]. Our suggested management paradigm is outlined in Figure 1 and described below [75].

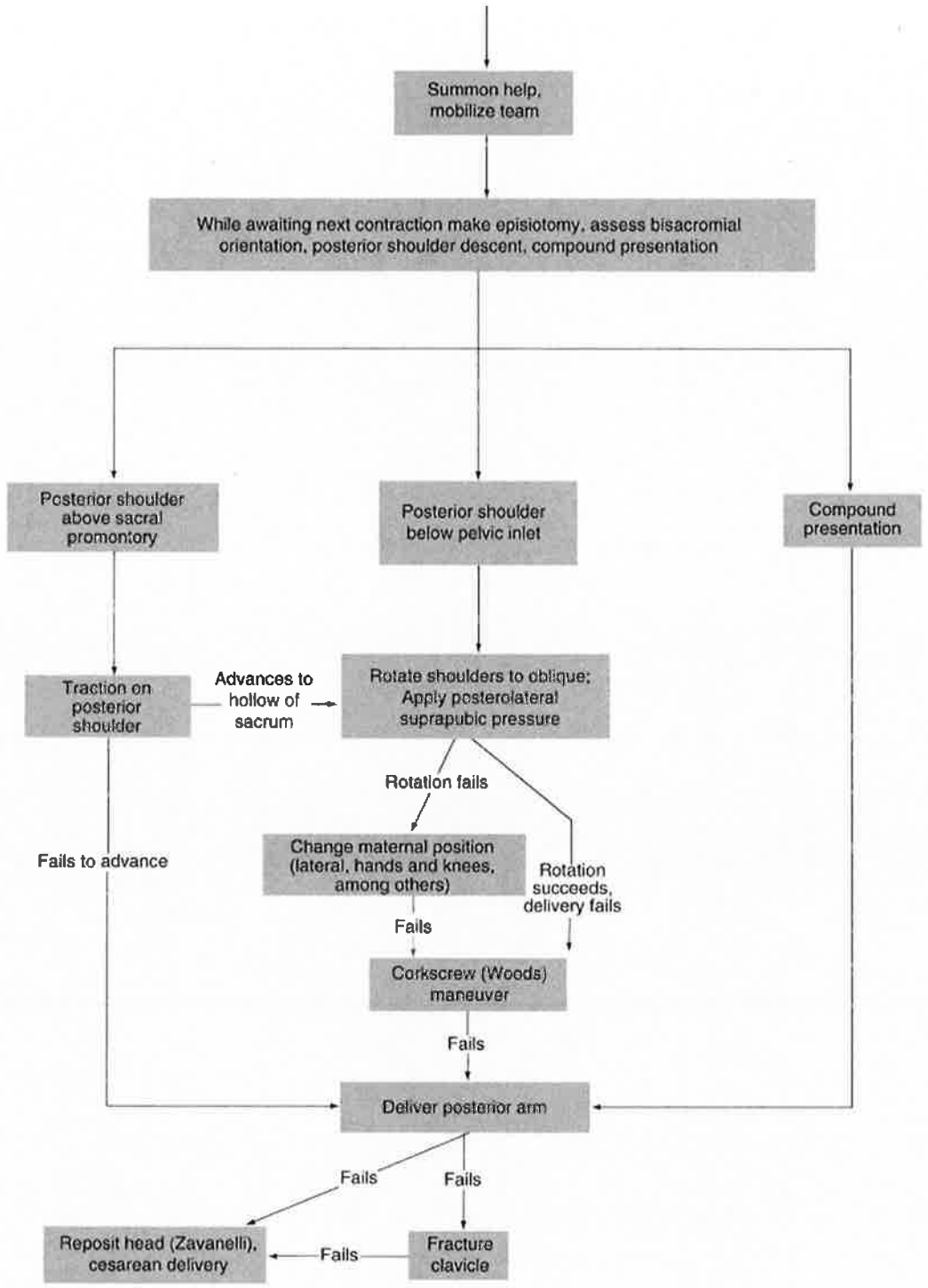

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Figure 1.

A logical paradigm for the management of shoulder dystocia. This approach works well, but the order of applied maneuvers should be modified according to the extant situation.

While its details may be modified to address individual or institutional preferences, availability of clinical resources and extant circumstances, the need to proceed with a logical sequence of assessments and maneuvers is paramount. A detailed description of the technical aspects of maneuvers to resolve shoulder impaction is beyond the scope of this review. For such information the reader is referred to

references 75–78. There is not strong evidence to support any sequence of manipulations as being superior to others. Most recommendations are based on clinical experience. Whatever maneuvers are used, it is important not to rush, to remain calm and to give clear instructions to the patient and assistants. Intense fundal pressure, downward traction on the fetal head or repeated forceful suprapubic pressure should be avoided, as these actions are likely to result in injury. An episiotomy may be appropriate. It will not relieve the obstruction, but will facilitate intravaginal or intrauterine manipulations.

When shoulder dystocia is suspected, often – but not always – by finding the baby's head retracted tightly against the mother's perineum, the management plan should be instituted. The best initial approach is not to touch the baby's head, no matter how tempting to do so. The brachial plexus may already be on tension, and it can take surprisingly little force to injure it. Rather, it is advisable to await the next contraction before instituting any maneuvers [76]. Use the intervening time to assess the situation by thorough examination, to summon necessary help and to explain to the patient and the team what is to be done. The mother should be encouraged not to push until a shoulder is emerging, and fundal pressure should generally be avoided. The most experienced obstetrician available should take charge of management.

The presence of a protocol, unique to each institution, is vital. Once triggered by personnel at the delivery a series of events should be set in motion so that help is summoned. An experienced obstetrician and obstetrical nurse are important, as may be a neonatologist and anesthesiologist. If the patient was deemed to be at very high risk extra help should be immediately available in anticipation of difficult shoulder delivery.

A careful examination of the patient should be done, with a focus on several things. Determine the orientation of the shoulders in the pelvis, assess whether the posterior shoulder has negotiated the sacral promontory and entered the midpelvis and rule out a compound presentation. Reassess the subpubic angle and the inclination of the lower sacrum and coccyx. If the posterior shoulder is unengaged or there is a limb presenting alongside the head, problems that complicate a few percent of shoulder dystocias, these should be dealt with promptly. If not, and the anterior shoulder does not stem beneath the symphysis pubis with the subsequent contraction, attempt rotation of the shoulders into an oblique diameter of the inlet (Rubin maneuver) [77]. If rotation is not possible, consider delivery of the posterior arm. If rotation occurs but delivery does not, continue rotation a full 180°, the Woods maneuver [78].

When the lead provider is attempting to rotate the shoulders it is advantageous for an assistant to facilitate rotation by applying pressure to the anterior shoulder suprapubically. This pressure should be directed posterolaterally in the same direction as vaginal attempts by the lead provider so as to encourage rotation of the trunk. Suprapubic pressure directed posteriorly will not accomplish that goal.

Delivery of the posterior arm

Go to:

The posterior arm will usually be extended, and require flexion so that the hand can be grasped and the arm pulled across the fetal chest. Once the posterior arm is delivered, the anterior shoulder will usually emerge easily. Computer simulation suggests that this approach might involve less stretch applied to the brachial plexus when compared with suprapubic pressure or rotation of the fetal shoulders [79] and, when it can be accomplished, is highly effective in relieving the obstruction [80]. Fracture of the humerus is not an uncommon complication of posterior arm delivery, especially when flexion of the elbow is difficult or impossible. Most such injuries heal well.

Extreme maneuvers

Go to:

Clavicle fracture

When more conservative approaches fail, intentional fracture of the clavicle may relieve a shoulder dystocia. In fact, spontaneous fractures are not often associated with BPI, probably because the collapse of the shoulder girdle precludes the problem. The posterior clavicle is generally most accessible. Careful technique is required to avoid injuring the subclavian vessels or the apex of the lung.

Zavanelli maneuver

When all attempts to relieve shoulder obstruction have failed, the Zavanelli maneuver is an option. The fetal head is flexed and pushed back into the uterus, reversing the movements of the preceding mechanism of labor. Expeditious cesarean is then done. There are case reports and case series detailing the use of this maneuver, with mixed results [81–83]. During the time before delivery, death or permanent peripheral or central nervous system injury may have already occurred [81]. However, the technique can be successful, with excellent maternal or neonatal outcome [82]. Because it is done so infrequently, and not all cases are reported, it is impossible to evaluate the relative risks and benefits of the Zavanelli maneuver.

Symphysiotomy

This procedure, which involves surgical division of the symphysis pubis via an incision in the mons veneris, is performed rarely in the developed world, although it does have advocates [84,85]. In cases of intractable shoulder dystocia, often after a failed Zavanelli maneuver, it has been used as a last resort [86]. Injury to the urethra, an unstable pelvis and chronic osteitis pubis can complicate the procedure and recovery.

Atypical presentations

Go to:

Maneuvering the posterior shoulder into the sacral hollow

When initial examination after diagnosis of suspected shoulder dystocia finds the anterior shoulder impacted behind the symphysis and the posterior shoulder above the sacral promontory, most maneuvers will be of no avail until the posterior shoulder is engaged. To accomplish this, place traction on the fetal scapula or, if necessary, the axilla, pulling the shoulder into the sacral hollow. The movement of the shoulder into the pelvis from above the inlet will allow manipulation of the shoulders or posterior arm to facilitate delivery. The use of an axillary sling to manipulate the posterior shoulder has been advocated [87].

Compound presentations

The presence of a prolapsed arm or a leg adjacent to the head can cause shoulder dystocia, and identifying a compound presentation is vital before any of the usual maneuvers is initiated. The limb may remain in the vagina once the head delivers, or may be completely prolapsed. If it is a leg and cannot be easily repositioned, cesarean will be necessary. If it is the posterior arm, attempt to deliver it directly, and if the anterior arm presents, do a Woods maneuver to move it posteriorly to facilitate its delivery.

Rare sources of dystocia

Rarely, what appears to be shoulder dystocia is caused by other obstructive phenomena. A large sacrococcygeal teratoma, conjoined twins or fetal ascites can prevent delivery of the fetal body after the head emerges. In these situations, some clues from the physical examination can be helpful, and ultrasound imaging in the delivery room may make the diagnosis and guide therapy. Cesarean delivery

is usually necessary, although in the case of ascites needle drainage can sometimes be done to diminish the abdominal circumference.

McRoberts maneuver

Go to:

The McRoberts maneuver, which came into popular use in the early 1980s, is often recommended as the first maneuver to use in a case of shoulder dystocia. It has the advantages of simplicity, ease of application and no requirement for skillful manipulation. Full flexion of the mother's knees and hips against her abdomen may alter pelvic dimensions to favor delivery [88]. It is successful in a substantial number of cases [89]. However, in severe cases when the McRoberts maneuver does not work it may in fact contribute to the occurrence of BPI, and for this reason we do not recommend its use. The rotation of the pubic symphysis may draw the impacted anterior shoulder away from the head fixed at the introitus, thus introducing further tension on the already stretched brachial plexus roots. Moreover, when this procedure is used, it is often accompanied by unnecessary and potentially harmful downward traction on the head and suprapubic pressure. It does not work prophylactically, and potentially places more tension on the fetal neck than maneuvers that involve manipulation of the shoulders [2,90–92]. Adoption of McRoberts maneuver has been associated with an increased incidence of BPI over time [12], despite the increasing rate of cesarean delivery among macrosomic babies [93,94].

Maternal position

Go to:

The importance of maternal posture requires emphasis. Most deliveries occur with the mother in a modified lithotomy position. All of the maneuvers described for manipulation of the fetus tend to be described from this perspective, which is most convenient for the attendant, but not always the most comfortable for the parturient. In fact, reports, admittedly anecdotal, from situations in which alternative positions for delivery are the norm suggest very low rates of shoulder dystocia. The use of the lateral position, or even squatting or kneeling on hands and knees should be considered for deliveries in which there is a high risk of shoulder dystocia. Moreover, these positions may be valuable in the management of obstructed shoulders and should be strongly considered if initial attempts at rotation of the shoulders are unavailing. These options can be limited by epidural anesthesia or by patients who find it difficult to change position. The Gaskin maneuver (moving the patient onto her hands and knees) and the lateral position often result in spontaneous or easily expedited delivery of the posterior shoulder [3]. If necessary, delivery of the posterior arm is often facilitated by these positions.

Conclusion

Go to:

Shoulder dystocia is infrequent but has potentially serious consequences. It can be prevented by performing preemptive cesarean delivery on cases at very high risk, but our ability to identify such cases is still limited. Prompt diagnosis and optimal management of shoulder dystocia when it occurs is the key to preventing permanent neurologic sequelae. Management requires the coordinated efforts of a team with the requisite skills. The team leader should direct the management and institute a series of maneuvers to extricate the fetus with minimal risk to it and the mother. A thorough understanding of relevant pelvic and fetal anatomy is necessary as well as of the mechanisms through which the dystocia can be resolved. Maneuvers that involve manipulation of the fetal shoulder girdle confer less tractile force on the fetal brachial plexus than manipulations of the mother or of the fetal head or neck.

Future perspective

Go to:

To reduce the frequency of BPI, especially that associated with difficult shoulder delivery, will require progress on two seemingly paradoxical fronts. First, we must harness the ability of decision support software in electronic obstetric records to present the clinician with updated risk assessments during the course of pregnancy and labor. The supporting algorithms must be population-specific and be modeled

so as to consider all relevant variables that might impact risk while there is still time to avoid hazardous vaginal delivery. Each hospital or governing organization will need to set thresholds for the number of cesareans that is an acceptable trade-off for preventing a BPI.

In addition to this futuristic approach there is a need to revisit education in some basic obstetric principles. The importance of clinical cephalopelvimetry and accurate identification of dysfunctional labor patterns – both arguably diminishing skills – is necessary for the best possible information to be fed to the computer algorithms.

Study of the relative value of various maneuvers or sequences of maneuvers for management of shoulder dystocia could, in theory, be accomplished in a series of randomized clinical trials. Such studies would be difficult to design because of the many potentially confounding variables to take account of, would require very large multi-institution samples, and would be very expensive and complex.

Executive summary

Executive summary

- Shoulder dystocia occurs in 0.15–2% of all deliveries.
- Brachial plexus Injury is diagnosed in up to 20% of newborns after shoulder dystocia. Injury is transient in most, but can lead to serious permanent disability.

Risk factors

- Risk factors can be identified in the patient's history and during prenatal care and labor. Most prominent are a history of prior shoulder dystocia or brachial plexus injury, current fetal macrosomia, maternal obesity, diabetes mellitus, excessive weight gain and dysfunctional labor patterns, especially a long deceleration phase followed by a long second stage.

Prediction

- Prediction of this complication is imperfect, but many cases can be avoided by taking multiple risk factors into account and delivering the highest risk cases by preemptive cesarean. Risk assessment is best accomplished by multivariate analysis, but current systems can predict only about a third of cases.

Clinical management

- Skillful use of a logical series of maneuvers can prevent injury in many cases. Staff training and simulation exercises are helpful to prepare for management of this emergency.
- When shoulder dystocia is suspected it is useful to await the next contraction before initiating any maneuvers. Traction on the fetal head and neck should be scrupulously avoided.
- Initial maneuvers should focus on rotation of the fetal shoulders. If unsuccessful, delivery of the posterior arm is usually helpful, as is moving the mother into a lateral or hands-and-knees position.
- Limited data exist on the effectiveness and safety of intentional clavicle fracture, the Zavanelli maneuver and the use of symphysiotomy. They could be considered, however, in desperate cases.

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Financial & competing interests disclosure

Go to:

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

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Prevention of shoulder dystocia related birth injuries: Myths and facts

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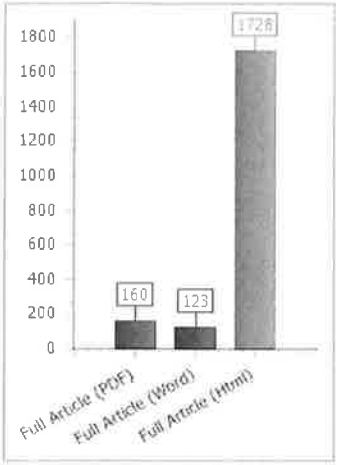
Abstract

Traditionally, brachial plexus damage was attributed to excessive traction applied on the fetal head at delivery. Recently, it was proposed that most injuries occur spontaneously *in utero*. The author has studied the mechanism of neurological birth injuries based on 338 actual cases with special attention to (1) fetal macrosomia; (2) maternal diabetes; and (3) methods of delivery. There was a high coincidence between use of traction and brachial plexus injuries. Instrumental extractions increased the risk exponentially. Erb's palsy following cesarean section was exceedingly rare. These facts imply that spontaneous neurological injury *in utero* is extremely rare phenomenon. Literary reports show that shoulder dystocia and its associated injuries increased in the United States several-fold since the introduction of active management of delivery in the 1970's. Such a dramatic change in a stable population is unlikely to be caused by incidental spontaneous events unrelated to external factors. The cited investigations indicate that brachial plexus damage typically is traction related. The traditional technique which precludes traction is the optimal method for avoiding arrest of the shoulders and its associated neurological birth injuries. Effective prevention also requires meticulous prenatal care and elective abdominal delivery of macrosomic fetuses in carefully selected cases.



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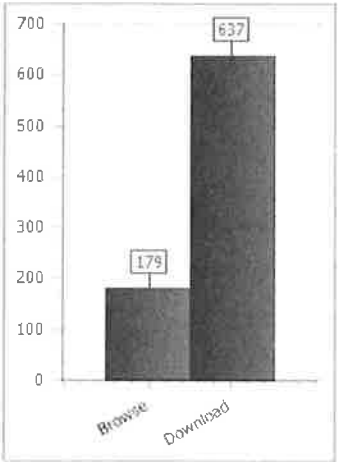

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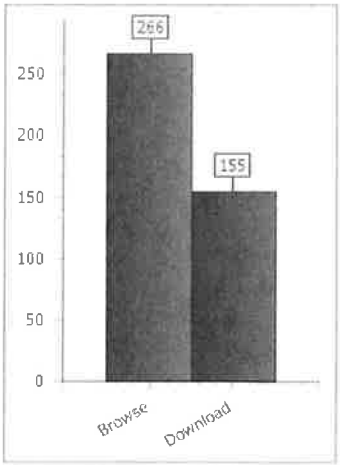

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Core tip: Traditionally, brachial plexus injury at birth has been considered traction related. Recently, several authors proposed that one-half or more of these injuries occur spontaneously "*in utero*" resulting from myometrial activity. Study of 338 birth injuries found close association with deliveries that had involved manual and instrumental extractions. Only one Erb's palsy occurred following cesarean section. These findings indicate that spontaneous intrauterine brachial plexus damage is extremely rare. Meticulous antenatal care, elective abdominal delivery of grossly macrosomic fetuses and non-interference with the natural birthing process are recommended for preventing shoulder dystocia and its dire consequences.

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INTRODUCTION

Since the 19th century double blind, controlled, prospective investigation has been the hallmark of scientific pedantry. However, not all medical puzzles yield themselves for evaluation by this important but costly and time consuming research approach. Injuries associated with arrest of the shoulders of the fetus at birth are eminent examples. Untold numbers of neonates are left with neurological damage following this complication every year, yet in any single service its incidence is low. Many newborn babies would need to be sacrificed at the altar of pure science if investigators insisted on resolving this problem through this revered gold standard of research. Not since the Aztecs had offered the hearts of forty-thousand slaves to their gods have human lives been considered freely expendable for causes that contemporary society found noble and worthwhile.

Medical history shows that sophisticated methodology, whatever valuable is no substitute for intuition and deductive logic. The latter qualities made it possible for open minded scientists, such as Jenner, Lind, Holmes, Semmelweis, Pasteur, Koch, Sanger, M and P Curie, Fleming, Gregg, McBride, Friedman, Clarke and others to promote the progress of medicine. Rigid demand for experimental evidence delayed for four decades clinical implementation of "asepsis" for the prevention of childbed fever at the cost of tens if not hundreds of thousands of lives.

Not unlike in ancient Egypt, physicians face court action in the United States if their treatment entails bad outcome. Mercifully, monetary compensation has replaced death penalty that had been favored in the valley of the Nile 3000 years ago. As a result, medical documentation of incidents of birth injuries that are scattered in hundreds of hospitals can be found in abundance in the files of malpractice attorneys and insurance companies. The author's group gained access to these sources and collected 338 medical records which described shoulder dystocia related fetal injuries or deaths in detail. As explained in previous publications[1,2], in many cases the attorney's preliminary review was not followed by litigation. In those instances when court action ensued the records were only attached to the data base after the legal proceedings had been concluded. Eventually, cases were collected on the ground of the following criteria: (1) Neonatal brachial plexus damage that persisted for at least 6 mo with or without clinical diagnosis of shoulder dystocia; (2) Damage-other than brachial plexus palsy-that persisted at least six months with clinical diagnosis of arrest of the shoulders at birth; and (3) Perinatal death against the background of documented shoulder dystocia at birth.

The diagnosis of shoulder dystocia was mentioned in over 90% of the records. The remaining ones only referred to brachial plexus injury. Absence of documented diagnosis is considered by some investigators evidence to indicate that the brachial plexus palsy occurred without arrest of the shoulders[3]. This distinction is only relevant in the medico-legal context, since the injury has never been attributed to the arrest of the shoulders but to traction used by the physician or midwife in

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charge. Therefore, for the purpose of their studies the participants of this research included those cases in their material where brachial plexus injury occurred but the diagnosis of shoulder dystocia was not documented.

DEFINITION OF SHOULDER DYSTOCIA

Paradoxically, this important clinical complication has no generally accepted criteria. According to current American interpretation the diagnosis is applicable when in the absence of spontaneous expulsion of the fetus the "standard delivery procedure of gentle downward traction" of the fetal head fails to accomplish delivery. This definition ignores the fact that routine use of traction is disapproved in some European countries[4,5] and was discouraged in the United States also until the mid-1970's[6-9]. Non-interference with the birthing process is still practiced by British obstetricians[4,10], whose proverbial "cold blooded" detachment much impressed this writer during the years of his training in England. It has also been favored in the Perinatal Center of the UMDNJ in Newark throughout the last 40 years[11] in spite of the contrary advice of standard textbooks and of the American College of Obstetricians and Gynecologists (ACOG). By traditional interpretation interruption of the delivery process following expulsion of the fetal head is a physiological phenomenon which does not warrant intervention. It occurs at least in one-half of the deliveries of primiparous women and in about one-fourth of all multiparas. The next uterine contraction which seldom is delayed more than 2-3 min expels the body of the child spontaneously. The time interval can be shortened by administering slow intravenous infusion of oxytocin in low concentration.

Conservative interpretation of normal birthing process affects the criteria of shoulder dystocia since only when the next contraction fails to expel the body becomes this definition applicable. Therefore, with this technique the diagnosis is objective and does not depend on the judgment of the accoucheur. It is a matter of note that in the practices of physicians who embrace this approach the incidence of shoulder dystocia tends to be low[12,13].

Interpretation of the so called "turtle sign" differs for those who accept the conservative concept of shoulder dystocia from that of others. Retraction of the head from the perineum following relaxation of the uterus is considered a physiological phenomenon which requires no intervention. The fetal body is likely to be delivered spontaneously with the next contraction. It is true however, that "real" shoulder dystocia relatively often is preceded by turtle sign. It should be regarded therefore a warning about possible forthcoming arrest of the shoulders rather than a diagnostic sign of it. Most importantly, its occurrence should be considered a relative contraindication for any attempt at delivery before the next uterine contraction.

There has been some dispute about the question of whether even a short waiting for the spontaneous expulsion the fetal body is warranted before the use of traction[14]. For reason to be discussed later, the idea of prompt traction reflects unawareness of the normal mechanism of the birthing process. Because the author considers any interference at this stage of the delivery ill-advised, this subject is outside the scope of discussion at this point.

FETAL EFFECTS OF ARREST OF THE SHOULDERS

In the absence of consensus about the diagnostic criteria of arrest of the shoulders the rate of fetal damage associated with it cannot be determined. In the Perinatal Center in Newark head and body have been delivered during separate uterine contractions in about 1 out of 3 instances. Such cases were described in the records as normal spontaneous vaginal births. Obviously, some of these deliveries would have been labeled as shoulder dystocia elsewhere. Thus, the statistics of those doctors who "pull" routinely differ from those who "do not pull". Like apples and oranges, the results of these groups cannot be compared. Therefore, the impression deriving from the literature, namely that about 1 out of 10 cases of shoulder dystocia entails lasting fetal damage is an educated guess at best.

The characteristic damages associated with arrest of the shoulders are Erb's and-less often-Klumpke's palsies. Neurologists generally endorse the opinion that these are traction related injuries[15]. Rarely, the lesion may be bilateral. Fractures of the scull, clavicle and humerus are relatively frequent and so are intracranial hemorrhage and hypoxic brain damage[16]. The latter ones can be life threatening and may occur with or without brachial plexus affliction. Injuries of the spinal cord and the phrenic nerve are rare. Minor brachial plexus lesions that are apparent at birth usually disappear after a few weeks or months. These are probably pressure rather than traction related injuries. Afflictions that persevere for more than six months are likely to remain permanent.

PREDISPOSING FACTORS FOR ARREST OF THE SHOULDERS

Factors listed in Table 1 have been found conducive to arrest of the shoulders at delivery. Because their significance varies on a broad range, only those considered of major clinical importance require discussion in some detail.

Table 1 (http://www.wjgnet.com/2218-6220/full/v3/i4/148-T1.htm) **Predisposing factors for shoulder dystocia.**

Preconceptional	Prenatal	Intrapartum
Small maternal stature	Low glucose tolerance	Protracted latent phase
Obesity	Preeclampsia	Protracted labor (1st stage)
Diabetes (or family history)	Gestational diabetes	Protracted labor (2nd stage)
High maternal birth weight	Large for gestational age fetus	Conduction anesthesia
Past birth of LGA child	Excessive weight gain (> 18 kg)	Use of oxytocin
Narrow pelvis	Postdatism	Arrest of labor
Past incidence of shoulder dystocia	Postmaturity	Vacuum extraction
"Elderly" primigravida	Induction of labor	Forceps delivery

LGA: Large for gestational age.

Pelvic contraction

The importance of feto-pelvic relations is obvious even for the uninitiated. The expediency that a large head cannot pass through a small opening was already taken into account by medieval architects when they built the dungeons of Castel Sant' Angelo in Rome, the Bastille in Paris and the Tower of London. Manufacturers of kings' crowns and men's hats used this knowledge even earlier. Unfortunately, physicians failed to take notice of this information until the 17th century. Consequently, "midwifery" practiced by granny midwives only turned into "obstetrics" after Mauriceau[17] had recognized the importance of the relationship between the size of the fetal head and the capacity of the mother's pelvis. Considering this background and the information that even a low for gestational age infant may encounter severe shoulder dystocia in case the pelvis is inadequate[18], the fact that some current texts describe not only antepartum but even intrapartum pelvic assessment unnecessary represents a romantic and adventurous but ill-conceived return to the Middle Ages. Also surprising is the fact that in spite of the well-recognized role of diabetes in the causation of fetal macrosomia, shoulder dystocia and other serious complications, antenatal diabetic screening in the absence of predisposing factors was still labeled unnecessary relatively recently[19].

Obesity

It is a widespread misconception that danger of postoperative complications makes abdominal delivery in morbidly obese women undesirable. Since their risks increase when cesarean section is performed after protracted labor and also because arrest of the shoulders may be as much as 10-times more frequent in this group than in the general population, gross obesity frequently makes cesarean delivery the preferable choice[20]. While reviewing cases of arrest of the shoulders at delivery it became apparent that far too often little attention had been paid to maternal weight increase during pregnancy. Insofar as obesity is conducive to diabetes and thus to excessive fetal size, the importance of preventing undue maternal weight gain by restricting its gestational increase to 10-12 kg with appropriate diet is readily apparent.

Past history of shoulder dystocia

Previous shoulder dystocia is widely considered an indication for cesarean section. While a desirable choice in most instances, trial of labor may be a reasonable alternative when predisposing factors that prevailed in the preceding pregnancy (such as gestational diabetes, fetal macrosomia, protracted labor and difficult forceps extraction) are not present or appear avoidable.

Conduct of delivery

Interference with the physiological birthing process has been so widespread in recent decades that probably few obstetricians have witnessed a normal spontaneous labor and delivery during their career. In the course of its passage through the pelvic inlet the sagittal suture of the skull is in or close to the transverse diameter. As the head enters the mid-pelvis the caput rotates 90 degrees. In 96% of the instances the small fontanel moves anteriorly. It is under the symphysis when the caput reaches the outlet. These turns and the descent itself are brought about by uterine contractions and represent passive accommodation to the available space. After the emergence of the head expulsion of the fetal body is preceded by another 90 degree rotation around its axis, since the chest cannot pass between the sciatic spines unless the shoulders occupy the antero-posterior diameter of the pelvis. This process brings about "external rotation of the head" on the maternal perineum. In a considerable minority of deliveries the contraction stops after the emergence of the head but before its external rotation. It only occurs 2-3 min later. This process called "2-step delivery"[11] is a physiological phenomenon and

carries no inherent risk[4-13,21-23]. Evidence of fetal compromise on electronic monitoring rarely justifies extraction of the body since the associated stress exacerbates preexisting hypoxia and may lead to meconium aspiration. Use of traction before external rotation of the head is futile and stressful for the fetus because the shoulders cannot traverse the pelvis in transverse rotation. It follows therefore that traction immediately after the delivery of the head invites arrest of the shoulders and may lead to Erb's palsy. For this reason, apart from major degree of abruption of the placenta or uterine rupture almost no situation calls for manual traction within the 3-4 min time frame of spontaneous vaginal delivery.

Tight umbilical cord around the fetal neck should be slackened but the temptation to extract the fetus must be resisted. While delivering the body the uterus compresses the chest and expels amniotic fluid and meconium from the respiratory tree (Figure 1). Cutting the nuchal umbilical cord prior to delivery of the shoulders is a dangerous polypragmasy which has no place in obstetrical practice[22,24].

(http://www.wjgnet.com/2218-6220/full/v3/i4/WJOG-3-148-g001.htm)

Figure 1 The picture illustrates a "2-step delivery" complicated by umbilical cord around the fetal neck. External rotation occurred shortly after the expulsion of the head and the delivery process stopped at that point. The cord was loosened but no attempt was made to extract the body. The picture taken at the onset of the next uterine contraction depicts its effect, namely expulsion of amniotic fluid from the respiratory tract (arrow). Since external electronic monitoring had demonstrated variable fetal heart rate decelerations at the end of the 2nd stage of labor, the cord complication was anticipated. Courtesy of Dr. Vivic Johnson.

In medicine as much as in everyday life to prevent a mishap one must know what brings it about. With regard to prevention of brachial plexus injuries, for reasons that go beyond the boundaries of medical science this question has become a battle ground of conflicting opinions: (1) Almost one-half of obstetrical malpractice claims relate to shoulder dystocia in America; (2) Skyrocketing malpractice premiums have forced capable doctors into early retirement; (3) Prodigious expenses of legal procedures have augmented the costs of maternity care; (4) The high costs of malpractice actions hindered the introduction of a national health care system; (5) Escalating brachial palsy cases required opening of neuro-surgical units specializing in Erb's palsies; (6) Contradictory opinions have left doctors without guidance about the conduct of labor and delivery; (7) Obstetricians' obvious confusion has undercut patients' confidence in their knowledge and integrity; (8) The prevailing state of affairs turns capable medical students away from the specialty of obstetrics; and (9) Search for quick remedy obscures the fact that preventing birth injuries is the only long-term solution. Although contradictory views in medical publications dealing with this subject tend to confuse the picture, the basic issues are not particularly complex.

According to traditional thinking Erb's and Klumpke's palsies are physical injuries caused by use of excessive force during the extraction of the child from the birth canal. This concept is still favored by obstetricians in some foreign countries and probably everywhere by neurologists[15,21]. In contrast, among American obstetricians the idea that most injuries develop "*in utero*" spontaneously has gained wide acceptance[25-29]. It is understandable, that it struck a favorable cord in the hearts of practitioners. If Erb's palsies are spontaneous "*in utero*" injuries then there is no cause for self-doubt or self-reproach. Besides, this idea offers a firm ground for defending malpractice claims. If most injuries occur spontaneously, physicians are immune against litigations because it can never be alleged that "more likely than not" the damage derived from medical error. Formal acceptance of this concept would promptly end many obstetrical malpractice claims and could reduce insurance premiums by 40% or more. It is hardly surprising therefore that the arguments about the merits of the respective points of view have gone beyond the limits of disciplined academic dispute. Therefore, it amounted to an impressive example of professional integrity that a prominent protagonist of the "*in utero*" injury concept withdrew his initial claim when he recognized that the results of his animal experiments had been misinterpreted[27].

Conduction anesthesia during labor

Since it was recognized during the early days of spinal and epidural anesthesia that it had significant side effects, concern was expressed about the desirability of its routine use[30]. The untoward effects of conduction anesthesia fall into four major categories[31]: (1) Cardiovascular toxicity; (2) Maternal and fetal central nervous system toxicity; (3) Reduced uterine blood flow; and (4) Decreased uterine contractility.

Clinically, these effects manifest in convulsions, hypotensive episodes, cardiac arrhythmias leading to cardiac arrest and lasting neurological damage by injection into the spinal canal rather than into the epidural space. Eventually, in the absence of medical consensus it was women's demand that turned epidural anesthesia into a routine procedure[32].

Fetal macrosomia

Large fetal size plays a major role in arrest of the shoulders at birth[16,33-38]. However, it has been problematic to quantitate the magnitude of the risk[39]. Therefore, concern about increasing cesarean section rates induced professional organizations to encourage practitioners to deliver markedly large for gestational age (LGA) fetuses vaginally[40]. Apparently reassured by the claim that 50% or more of all brachial plexus injuries are spontaneous "*in utero*" events, as recently as 2002 and 2005 the ACOG[41] and the Royal College of Obstetricians and Gynaecologists (RCOG)[42] advised physicians to deliver fetuses of diabetic mothers weighing as much as 4500 g and those of non-diabetic women up to 5000 g vaginally and to use traction if the body does not soon follow the head.

In the course of a review of cases of shoulder dystocia related birth injuries that had occurred between 1960 and 2007 the author's group evaluated the distribution of birth weights of affected neonates[16]. The findings summarized in Table 2 show that a relatively small group of macrosomic babies suffered the overwhelming majority of injuries. The weight related increase of permanent damage showed a logarithmic curve rather than a geometric line. This finding implies that danger of underestimating fetal weight exceeds that deriving from overestimation.

Table 2 (http://www.wjgnet.com/2218-6220/full/v3/i4/148-T2.htm) Birthweight distribution in 316 cases of fetal damage associated with shoulder dystocia[1].

Birth weights	Number of cases	Percentage of total
2500-2999 g	6	2%
3000-3499 g	20	6.0%
3500-3999 g	68	21.5%
=	=	=
4000-4499 g	107	34%
-	-	-
4500-4999 g	72	22%
5000-5499 g	32	10.5%
5500-5999 g	9	3%
≥ 6000 g	2	0.5%

=: Traditional borderline for macrosomia; -: New American borderline for macrosomia. Based on traditional standards, less than 10% of all fetuses qualify for the definition of macrosomia. In this material 70% of all birth injuries were sustained by neonates belonging to this group. [1]Tables 2-4 show the results of mathematical calculations presented in previous publications. Copies of original articles containing details of the data analysis by the group's biostatistician can be obtained from the author.

Based on the above mentioned evidence the risks of damage for individual fetuses belonging to various weight groups were evaluated next. The calculation took into account the birth weight distribution in the United States[43] along with the information that about 1 out of 100 deliveries involve shoulder dystocia[44] and 1 out of 10 such newborn babies sustain permanent injury[45]. The results of this calculation are indicated in Table 3.

Table 3 (http://www.wjgnet.com/2218-6220/full/v3/i4/148-T3.htm) Birth weight associated risk of shoulder dystocia related fetal injury at delivery.

Birth weight	National average	Sample	Estimated risk of damage
Under 3000 g	24%	2%	1:12000
3000-3249 g	17%	2%	1:8500
3250-3499 g	20%	4.5%	1:4444
3500-3749 g	16%	12%	1:3333
3750-3999 g	13%	9.5%	1:3368
4000-4249 g	5.5%	20%	1:275
4250-4499 g	3%	14%	1:214
4500-4749 g	0.8%	14%	1:57
4750-4999 g	0.3%	8%	1:37
5000-5249 g	0.2%	8%	1:25
≥ 5250 g	0.2%	6%	1:33

In previous publications the author arbitrarily defined "acceptable" risk for fetal injury as 1% noting that the maternal risk of permanent injury in case of cesarean section is much lower. The table shows that the limit of acceptable risk is already exceeded at the 4500 g level and increases to 3%-4% when the fetal weight is 5000 g or more.

The investigated cases derived from 40 states or districts of the Union. The mothers' parity ranged from zero (112 cases) to more than six (4 cases). Maternal ages ranged from 13 to 45 years with the majority of them falling into the middle range. The ratio of male *vs* female neonates was 51:49.

Birth injures included 259 incidents of brachial plexus damage, 32 cerebral palsies, 6 cases of mental retardations, 16 developmental delays, 12 traumatic cerebral bleedings, one spinal cord dissection, and 8 perinatal deaths. The method of delivery was spontaneous on 200 occasions. Forceps were used for delivery 61-times, vacuum extraction on 41 occasions and both instruments (ventouse followed by forceps) 14-times. Several babies suffered multiple injuries. Three childbirths concluded by the Zavanelli maneuver[11] and cesarean section were included in the spontaneous vaginal delivery group.

According to reliable statistics[19], "in all series there is a two or threefold increase in the rate of cesarean delivery with high birthweight". This being the case, the gradually increasing frequency of fetal injuries in the LGA and macrosomic categories derived from a gradually diminishing number of vaginal deliveries of large fetuses. Obviously this circumstance biased the above presented results. When based on this knowledge the calculation was adjusted, it transpired that the actual risks for lasting damage in these groups were more than 2.5% when the weight exceeded 4500 g and 5% when the child weighed more than 5000 g. Evaluation of these findings even on the ground of high school mathematics permitted the conclusion that widely quoted and relied on statistics[39,40] had grossly overestimated the number of cesarean sections needed for preventing of one fetal injury.

Arguments against elective abdominal delivery on the basis of estimated fetal weight have often included the warning that sonography was likely to overestimate the fetal size. Review of the literature clarified however, that in the 5000 g danger zone ultrasound examinations underestimated the fetal weight in 80% of the instances[46-48]. This fact indicates that the real danger associated with reliance on sonography is failure of identifying some excessively large fetuses rather than overestimating those who are not unduly large.

Because maternal risks associated with abdominal delivery are substantially less, in the writer's opinion a chance of 1% for permanent fetal damage is the acceptable maximum in contemporary practice. Even this liberal view incorporates obstetricians' traditional prejudice, namely that the mother's life is more precious than that of her unborn child. Consequently, the final arbiter of any relevant decision has to be the pregnant woman whose tolerance concerning maternal and fetal risks may differ from that of her obstetrician or of the consensus of medical opinion.

Instrumental deliveries

Observant obstetricians drew attention to the fact several years ago that mid-forceps extractions had markedly increased the incidence of shoulder dystocia[49]. By the same token, in the authors' material shoulder dystocia related fetal injuries had often been preceded by forceps or ventouse extractions. Between 1973 and 2006 not less than 117 records referred to instrumental deliveries[50]. When the material was distributed into weight groups (less than 3750 g/3750-4499 g/4500 g or more), it was learned that extraction instruments were frequently used in each of them (37%/40%/27%).

Comparison between the various technical procedures was hindered by two circumstances: (1) The ACOG elected to change the criteria of mid and low forceps operations in the 1980's. Since some physicians continued adhering to the old definitions, the documentations with regard to the actual types of the operations were often inconclusive; and (2) Whereas a statement pertaining to the nature of forceps operations usually appeared in the records, the majority of ventouse users provided no explanation.

Among those forceps procedures where the nature of the operation was stated 2 were performed at the outlet, 27 were low forceps and 29 mid-pelvic operations. Three forceps, one ventouse and one ventouse-forceps procedures were marked as "high".

Although in the entire material about two-thirds of the deliveries were spontaneous, the incidents of central nervous system (CNS) damage in the spontaneous and instrumental delivery groups were close to equal (37 *vs* 33). Thus, the use of instrument almost doubled the risk of CNS damage.

The data permitted a comparison between spontaneous deliveries on the one hand and extractions by instrument on the other. The result of this calculation is shown in Table 4. The tabulation indicates that in most categories the risk of major injury was more than 10-times higher when forceps or vacuum extractor was used than when unassisted delivery of the child was allowed.

Table 4 (http://www.wjgnet.com/2218-6220/full/v3/i4/148-T4.htm) Risks of shoulder dystocia related fetal damage in spontaneous and instrument assisted deliveries.

Birth weights	Spontaneous deliveries	Instrumental extractions
Under 3500 g	1:5660	1:900
3500-3999 g	1:1740	1:110
4000-4499 g	1:204	1:24
4500-4999 g	1:41	1:6
≥ 5000 g	1:25	1:3

Birth weight related fetal risks for damage in cases of spontaneous *vs* instrument assisted deliveries. Note that use of extraction instruments increases the chance for fetal damage almost 10-fold.

This study does not support the claim that ventouse is more accident prone than forceps[51]. In fact the opposite was the case in this material. It transpires however, that both instruments augment the risks and that gradually increasing fetal weight increases them exponentially. The findings imply that one percent chance for fetal injury already prevails when extraction instrument is used for the delivery of a 4000 g fetus. Therefore, the author considers such a fetal weight the uppermost limit for a relatively safe extraction procedure in virtually any clinical situation. Undoubtedly, mid-cavity operations carry even higher danger.

Impaired glucose tolerance and diabetes

Routine glucose screening was not a requirement during those years while the medical records utilized for the here cited study were generated[52]. On this account evaluation of the predisposing effect for shoulder dystocia of maternal glucose intolerance was hindered. Only about two-thirds of all records contained reference to diabetic screening and some of these were not standard tests. Therefore, the information they provided was often equivocal. This circumstance limits the validity of the investigators' calculation, namely that whereas only 10% of all neonates weigh more than 4000 g in the general population, the rate is about 50% for diabetic mothers and 20% for those women with "predisposition"

for diabetes[53]. Typically, positive screening test followed by negative 3 h glucose tolerance test was considered indicative of predisposition. In the > 4000 g weight group the risk of birth damage was 5-times increased for infants of diabetic mothers and twice for those of pre-diabetics as compared to others. Birth weights exceeding 4500 g seem to be 10-times more likely to occur among babies of diabetic women than among those of non-diabetic ones[16].

In light of the data reviewed routine diabetic screening of all pregnant women and attentive treatment of the disease are considered absolutely necessary. Although good management must take into account many relevant factors, including pelvic dimensions, previous births, maternal diet and others, in most instances an estimated fetal weight of 4000-4200 g represents for the author the uppermost limit for vaginal delivery in case of confirmed maternal diabetes. Assessment of fetal weight and size by ultrasound should be considered an obligatory routine in case of suspicion of LGA fetal status.

EFFECTS OF PRACTICE PATTERNS

During the 50 years covered by the studies of the author's group, routine management of labor has changed in many respects. It is necessary therefore to consider the potential effects of new developments upon the birthing process and its complications.

Oxytocin

When the drug entered the market it often caused uterine hyper-stimulation. Later it was only administered in intravenous drip under electronic fetal monitoring. Therefore this side effect became substantially reduced. This being the case, although it is suspected to increase the chance for shoulder dystocia, the drug is unlikely to be a major predisposing factor for arrest of the shoulders since it did not affect its rate during its relatively liberal use in clinical practice between the 1950's and 1970's.

Electronic fetal heart rate monitoring

Dysfunctional labor predisposes for shoulder dystocia. Designed to register uterine activity and evaluate fetal condition, external monitoring combined with tokography is useful and innocuous. By allowing the obstetrician to eliminate abnormal labor patterns and thus avoid difficult deliveries, electronic monitoring substantially reduced the number of factors conducive to brachial plexus injuries.

Fetal scalp blood pH determination

The technique is difficult, costly, labor intensive, in untrained hands inaccurate and carries the risk of causing fetal infection. It enjoyed popularity initially and was used with relative frequency for three decades. The technique largely disappeared from clinical practice by the early 2000's. It is unlikely that it influenced the rate of shoulder dystocia.

The "labor curve"

During the first half of the 20th century dysfunctional labor was tolerated for long periods of time because a cesarean section rate of 5% was considered the acceptable maximum. Friedman's[54] research pointing out the dangers of protracted labor changed physicians' thinking. Introduction of fetal heart rate monitoring that allowed recognition of "fetal distress" had similar effect. As a result, by the 1970's cesarean section rates rose to 10%-15%. The bush fire no longer could be stopped. At the turn of the century the rate of abdominal deliveries reached 30% and then increased even further. While it's other effects are disputable, this development was bound to reduce the incidence of shoulder dystocia and the related fetal injuries for more than one reason: (1) The fact alone, that the number of vaginal deliveries decreased by almost one-third allowed the expectation that shoulder dystocia would be reduced by the same rate; and (2) Many abdominal deliveries are done for protracted labor predominantly due to large fetal size[19]. Thus a high proportion of difficult vaginal deliveries that were conducive to shoulder dystocia became replaced by cesarean sections. In effect, changes that turned "obstetrics" into "perinatology" were such in nature that they were bound to cut the prevailing rates of shoulder dystocia and its related fetal injuries markedly. Obviously, any theory addressing the subject of causation must explain why Erb's palsies have continued to increase in America despite a marked reduction of its predisposing factors.

MISCELLANEOUS FACTORS AFFECTING INCIDENCE OF SHOULDER DYSTOCIA

The above mentioned change in the management of the birthing process that had escaped critical evaluation for several decades diverted the investigations of the author's group to new directions.

Geographic variations

The rates of shoulder dystocia differ in various geographic areas and at various time periods. Examples are its increasing rate in the United States[55,56], a high proportion of brachial plexus injuries deriving from a moderate number of shoulder dystocia incidents in Sweden[57,58] and its infrequent occurrence

in the British Islands[42,59,60], Hong Kong[61] and Israel[62,63]. High birth weights of Swedish babies and relatively low weights of Chinese ones probably played a role in the quoted trends. This circumstance underlines the rule that conclusions based on one particular racial group do not always apply to others.

Chronologic fluctuations in the rates of shoulder dystocia

Disputes in America about the causes of shoulder dystocia have involved the contention that its incidence had not changed for decades[64]. The data presented in support of this claim included statistics from foreign countries where this complication had been rare. This arbitrarily mixed material did not reflect the state of affairs in the United States. Therefore, a computer search was undertaken. It yielded 20 reports that included 26 separate studies for the years of 1949-2005. The periods of observation ranged in the various studies from 1 to 10 years. The results deriving from these statistics are shown in Table 5.

Table 5 (http://www.wjgnet.com/2218-6220/full/v3/i4/148-T5.htm) Incidence of shoulder dystocia in the United States between 1949 and 2005.

Time periods (yr)	Number of reports	Ref. numbers of reports1	Average incidence per 100 births2
1949-1974	5	[55,65-68]	0.26%
1975-1990	10	[49,55,56,69,70-74]	1.22%
1991-2005	11	[56,74-81]	1.65%

[1]Two authors presented multiple reports;

[2]Some reports referred to number of cases per 100 vaginal births. These were adjusted under the premise that the rate of cesarean section was 20%. Note that the rate of shoulder dystocia increased almost 5-fold by the 2nd and more than 6-fold by the 3rd time period as compared to the 1949 to 1974 average.

The data reveal that arrest of the shoulders occurred rarely (about 2-3 out of 1000 births) prior to the mid-1970's. Its rates rose rapidly thereafter until and including the first decade of the current century. In some services the increase was as high as 10 to 15-fold. Thus, rather than having remained stable cases of arrest of the shoulders and its neonatal consequences increased exponentially in the United States since the 1970's. This development appeared mysterious for a variety of reasons: (1) Changes in practice patterns eliminated or markedly reduced the number of predisposing factors for shoulder dystocia since the 1950's; (2) While the incidence of arrest of the shoulders increased in America its rate remained stable in the British Islands; (3) Circulars from medical organizations inundated practitioners with instructions about the prevention and management of arrest of the shoulders in recent years; and (4) Few issues of obstetrical journals appeared without studies discussing shoulder dystocia related problems.

Because the turnaround happened in the 1970's, the author elected to study those changes that had taken place in the practice of obstetrics around that time. This inquiry brought into focus two articles published by Wood *at al*[82,83] in the leading British specialty journal in 1973. Utilizing the at that time novel scalp blood pH technic during normal deliveries, these investigators found that after the emergence of the head the pH of the capillary blood fell at a rate of 0.04 to 0.14 units per minute although the neonates had excellent Apgar scores. Presumably because the technique was as yet unreliable at that time, these papers generated little interest in Great Britain. In contrast, they caused concern in the United States. Without explaining why, new editions of textbooks announced that the fetus must be extracted from the birth canal following the expulsion of the head without delay[84,85].

Wood *at al*[82,83] inconclusive research certainly deserved rechecking in order to assess its clinical relevance. However, things went the opposite way. Practice patterns were modified overnight but only quarter of a century later were scalp capillary pH levels studied during the head-to-body delivery interval in well-equipped laboratories by investigators who had experience with the technique. Aware of the clinical implications of their research their attention focused on babies who encountered shoulder dystocia. They found that delayed delivery of the body did not alter capillary pH significantly[80,86,87]. Investigations by Gurewitsch[88] based on more than 200 cases revealed that delayed delivery of the body caused no clinically significant change in the fetal metabolic equilibrium for up to 8 min.

Perhaps the most persuasive contribution to this subject was the investigation of Locatelli et al[23]. These research workers undertook a prospective study involving 789 patients who gave birth by the conservative method. It was found that the mean head-to-body interval was 88 s and the decline of the umbilical artery pH was only 0.0078 units per minute. They concluded that spontaneous birth did not

significantly increase the risk on neonatal acidemia. Obviously, Wood et al[82,83] grossly overrated the decline of the fetal scalp blood pH during the delivery process. Thus, the reason for the still ongoing effort directed at shortening the head-to-body delivery time is difficult to understand.

In the opinion of the writer of this review the abrupt change in the management of the delivery process introduced into practice in the mid-1970's has been and remains the most important single factor responsible for the rapid increase of arrests of the shoulders at birth and the associated fetal neurological injuries in the United States.

It should be a matter of great concern that a group of investigators who had attempted in earnest to reduce the head-to-body interval to a minimum ended up with unprecedented 13.8% and 10.8% rates of arrest of the shoulders[89,90]. News of this "shoulder dystocia tsunami" raised no eyebrows among "fetal rescue" advocates. They reiterated a few years later: "Shoulder dystocia is an unpreventable obstetric emergency"[64].

Indeed, arrest of the shoulders is unpreventable if one prefers to believe that brachial plexus palsy has little to do with the method of delivery. Investigators who refrained from using traction during the birthing process, reduced the rate of this dangerous complication to the range of 0.2% without even trying[12,13].

On account of its adverse effect upon the practice of medicine, the fact that in the long run prevention of catastrophic birth injuries is the most effective approach to avoiding costly malpractice litigations deserves a brief mention in the context of the ongoing controversy[91].

Methods of delivery and shoulder dystocia

In order to evaluate the fetal effect of delayed delivery of the body after arrest of the shoulders, the writer's group reviewed in their medico-legal material those births that had occurred after 1974. Only 103 records documented the head-to-body intervals. Table 6 shows the relevant findings.

Table 6 (http://www.wjgnet.com/2218-6220/full/v3/i4/148-T6.htm) Head-to-body delivery times in 103 cases of shoulder dystocia related neonatal neurological damage.

Head-to-body interval	Number of cases
0-1 min	32
1-2 min	38
2-3 min	12
3-4 min	5
4-5 min	8
5-6 min	2
6-7 min	2
7-8 min	2
8-9 min	0
9-10 min	2

Note that in 82 instances (80%) delivery involving neurological injury of the child was accomplished within 3 min. Before 1973 these cases would not have been classified as shoulder dystocia. Because delay of the next contraction by 5 min does not endanger the fetus, the use of traction was unnecessary in the majority of these cases.

In a high proportion of the cases (42%) the 5 min Apgar score was less than five. Clinical experience shows that babies who are born spontaneously are in good condition even if the body is expelled with 5 min delay[11,88]. Thus, the low scores in this group most likely derived from stress caused by the extraction efforts.

Although the United Kingdom remained unaffected by the American shoulder dystocia crisis, the RCOG in 2005 endorsed the idea that the fetus must be extracted from the birth canal after the delivery of the head[42]. The "Guidelines" of the College cited the so called CESDI report in support of this advice stating that the investigation had found that 47% of babies who perished following deliveries complicated with shoulder dystocia "died within 5 min of the head having been delivered". Actually, members of the CESDI Committee emphasized that the adverse outcomes were unrelated to the head-to-body delivery intervals. They explained that the neonatal deaths had resulted from substandard

management of the labor and inadequate skills on the part of doctors in charge[92]. The misleading misinterpretation of the official report by the RCOG Guidelines was duly pointed out by this writer's group in a recent review article sponsored by the Royal Society of Medicine in London[93].

Research performed one century ago utilizing fetal cadavers showed that typical brachial plexus lesions could be induced by applying strong traction upon the fetal head against resistance[94]. More recent experimentation conducted by French neurologists confirmed the earlier findings[95]. Utilizing sophisticated methodology Allen produced evidence that supported a relationship between aggressive management of the birthing process and neurological birth injuries[96]. He concluded based on his experiments that brachial plexus lesions sustained at birth were traction injuries and demonstrated that when encountering strong resistance, physicians subconsciously double the effort that the extraction of a child under normal circumstances requires.

Based on an extensive review Gurewitsch et al[97] concluded that "the single greatest correlate with neonatal brachial plexus injury after shoulder dystocia is (the) degree of clinician-applied traction".

Brachial plexus injury and cesarean section

Disregarding the fact that the observed cases of brachial plexus "paresis" had been only transitory, it has been proposed that babies born without any traction suffered brachial plexus damage (*i.e.*, "paralysis"). It has also been claimed that Erb's palsies are frequent among babies born by cesarean sections.

In the material that included 338 fetal injuries typically related to shoulder dystocia, only one child sustained Erb's palsy during abdominal birth. The case in question was a term delivery by elective repeat cesarean section. During the operation the surgeon found extensive adhesions at the area of the previous lower segment transverse incision. He could not create adequate opening and it was with great difficulty that the child was extracted eventually through a small incision. This incident was rare enough to deserve publication. Based on the stated details the article presented the opinion that most likely this child sustained typical traction injury[98].

Ubachs et al[99] analyzed 130 brachial plexus injuries of which 28 were associated with breech extractions. The authors noted that all vertex deliveries involved extensive manipulation and concluded that none of the cases could be attributed to "intrauterine maladaptation". They emphatically pointed out that no injury in their material had been associated with cesarean delivery.

Most obstetricians have encountered cases where delivery of the shoulders across a small incision cut through an uneffaced cervix caused as much difficulty as arrest of the shoulders during a vaginal birth does. This being the case it seems likely that most of those extremely rare brachial plexus palsies that are associated with abdominal deliveries are traction related.

PREVENTION OF SHOULDER DYSTOCIA AND BRACHIAL PLEXUS INJURIES: CONTROVERSIAL ISSUES

Because education pertaining to its management has little if any effect upon the rate of fetal injuries associated with arrest of the shoulders[100], this complication needs to be avoided as far as possible. Since prevention requires understanding of the cause of the problem[101], any prevailing theory has to be consistent with established facts in order to prove its validity. Therefore, advocates of the respective concepts must be able to answer several relevant questions: (1) Why did the rate of shoulder dystocia increase exponentially in the United States during the last 40 years in spite of the fact that changing practice patterns eliminated many of its predisposing factors? (2) Why did the rate of shoulder dystocia remain stable in Great Britain while it escalated in America? (3) Why do instrumental extractions increase the rate of brachial plexus palsies exponentially? (4) Why is brachial plexus injury literary rarity among neonates delivered by cesarean section? (5) Why is maternal diabetes a strong predisposing factor for neurological birth injuries? (6) Why do most Erb's palsies occur in association with documented diagnosis of shoulder dystocia? (7) What experimental model supports the validity of the respective etiological theories? and (8) Does lack of diagnosis of shoulder dystocia indicate that Erb's was sustained spontaneously "*in utero*"?

The following are the answers of the author to these questions:

Question 1: The population of, and the living conditions in the United States have been stable during the 20th century. No new circumstance has emerged that could conceivably have caused fetuses to suffer Erb's or Klumpke's palsies *in utero* six-times more often than 50 years ago. The cause of the damage has to be therefore extrinsic.

Question 2: Up to 2005 the method of delivery remained conservative in the British Islands whereas it has been changed to "active" management in the United States. As a result, up to recently the rate of shoulder dystocia had been low in the United Kingdom[59,60,102].

Question 3: Should neurological injuries occur spontaneously *in utero* the use of ventouse or forceps could not affect their incidence. The documented relationship underlines the role of traction in the causation of injuries. Following instrumental extraction of the caput the uterus seldom expels the body within 30 or even 60 s. As a result, doctors adhering to active management are compelled to apply manual traction after the instrumental delivery of the head virtually invariably.

Question 4: Because 15% to 35% of all births involved the abdominal route in recent decades, the extreme rarity of Erb's palsy among cesarean babies is noteworthy. Obstructed labor accompanied by strenuous uterine activity is a frequent indication for abdominal deliveries. If the activity of the uterus had caused a significant proportion of brachial plexus injuries, Erb's palsies should be frequent among babies delivered by cesarean section on account of obstructed labor. However, this is not the case.

Question 5: Diabetes causes fetal macrosomia and broadens the shoulders out of proportion to the diameters of the head[33]. These effects predispose for arrest of the shoulders at birth and explain why big fetuses of diabetic mothers are particularly prone to suffering damage[50,53].

Question 6: The records reviewed by the authors were unselected and had been generated by many doctors and nurses in almost as many hospitals. Their references to shoulder dystocia were not influenced therefore by policies, interpretations or biases that may have been prevalent in some institutions or certain geographical areas. Had a high proportion of injuries been spontaneous "*in utero*" accidents there would have been no reason for them to coincide in > 90% of all instances with a complication (*i.e.*, shoulder dystocia) which only occurs once out of 100 deliveries.

Question 7: Experimental evidence supports the role of traction in the causation of Erb's and Klumpke's palsies[94,95]. No comparable evidence has been presented on behalf of the spontaneous "*in utero*" injury mechanism.

Question 8: This question is irrelevant to the pathological mechanism for several reasons: (1) The cause of brachial plexus injury is traction. Whether excessive pulling is done during or in the absence of arrest of the shoulders does not influence the mechanism of the injury; (2) With traditional delivery the criteria of shoulder dystocia are unequivocal. With active management the diagnosis is subject to the judgment of the accoucheur. It has therefore no objective validity; and (3) If one believes that the absence of shoulder dystocia proves that brachial plexus injury has occurred spontaneously "*in utero*", his or her judgment may become biased, even if subconsciously against acknowledging this diagnosis. Uninfluenced by such specious interpretation, more than 90% of the records in the author's data base that came from hundreds of different geographic locations, indicated that shoulder dystocia and brachial plexus palsies had occurred coincidentally.

Predicting shoulder dystocia

Reflecting unawareness of medical history, the dictum: "arrest of the shoulders cannot be predicted" has been repeated incessantly in recent years. Advocates of this truism must have overlooked that Jenner had not proposed only to vaccinate those unidentifiable children who had been singled out by Fate to contract smallpox. By the same token, Lind did not try to find out which ones of the embarking sailors for a voyage overseas would need a supply of fresh fruits in order to avoid scurvy. Similarly, Semmelweis did not restrict his aseptic measures to women whose destiny had been to roll in fever within a few days. Had these scientists wasted their time trying to "predict" the next victims of smallpox, scurvy or childbed fever, the secrets of these diseases would have remained unresolved for many more decades. In the same spirit, brachial plexus palsies must be avoided by general precautionary measures rather than by trying to determine who may need such protection next time.

Considering the present state of knowledge one must accept the probability that shoulder dystocia even in the best hands will continue to complicate two or three out of 1000 births for some time unless gifted soothsayers figure it out how to predict the victims. Until then, American obstetricians must live with the thought that only 80%-90% of currently prevailing brachial plexus palsies are preventable even if the urge of rescuing healthy babies from the womb is successfully resisted.

The causes of shoulder dystocia and the mechanisms of brachial plexus injuries are well understood. This problem is no different from many others that medical research has already resolved.

Basic principles concerning use of traction for delivery

It is a strange aspect of the shoulder dystocia controversy that the management of delivery is usually discussed as if long established concepts of modern obstetrics were fairy tales. Ever since the vacuum extractor had been introduced into clinical practice it has been a rule that traction should only be applied at the time of uterine contraction[103]. This requirement ensures that expulsive uterine force supplements traction, thus eliminating the need for using undue effort. In violation of this concept, instructions governing the management of normal delivery encourage doctors to apply traction 30 or 60 s after the emergence of the head; the time when the contraction has just ended. As a result, the

physician is forced to use more effort than would be needed if he waited for the next uterine systole. Although the latter would expel the fetus without intervention anyway, the risk of stretch injury could be already reduced if the obstetrician waited for a contraction and used traction in synchrony with it. That the condition of the fetus does not deteriorate between the contractions has been proven beyond any doubt[12,13,28,80,88]. Therefore, it defies elementary logic that an obstetrician who may have to wait several minutes for a contraction before delivering a severely compromised fetus with the ventouse, must extract a perfectly normal child by sheer force right after the expulsion of the head.

Medical errors leading to shoulder dystocia

Because the subject had been disregarded in the past, the role of the method of delivery in the causation of birth injuries has been stressed in this review. However, the records used for this research also revealed numerous departures from good obstetrical practice (not necessarily in conflict with minimum contemporary requirements) that were common denominators of the described accidents: (1) Assessment of the pelvic dimensions was often omitted or not documented in any detail; (2) Small maternal stature was ignored even if the mother was primigravida or had diabetes; (3) Frequently diabetic screening was either not done or equivocal test results were disregarded; (4) Confirmed diabetes seldom was treated effectively and only rarely with the involvement of an expert; (5) Excessive maternal weight gain seldom received attention and dietary instruction was rarely offered; (6) Frequently, not even by manual palpation was fetal weight assessed at or near term gestation; (7) Suspected LGA fetal status was not always evaluated with ultrasound; (8) Even if fetal macrosomia was suspected preparation for a difficult delivery was seldom made; (9) Some instrumental extractions of LGA fetuses were done without clear indication; and (10) Often only McRoberts maneuver, suprapubic pressure and manual traction were used for the management of shoulder dystocia.

It was a thought provoking feature of these unfortunate accidents that with relatively few exceptions not one single misjudgment but a combination of errors had led to neonatal injury. Correction of any one of them could have avoided the bad outcome on many occasions.

EPILOGUE

For physicians who due to indoctrination, habituation or temperament are addicted to rescuing babies from the birth canal the above shown list offers "Ten Commandments of Avoiding Shoulder Dystocia". With just a little luck they will find them helpful. For others who can be persuaded to allow mothers give birth naturally, the 11th Commandment: "Use two-step delivery!" may be the compass that guides them to the Promised Land where the rate of arrest of the shoulders is only 2-3 out of 1000 births. The return voyage there should not take another forty years. Some clever doctors from the United Kingdom, Israel, Ireland and Hong Kong have already found their ways there. Yet, it may be a worrisome journey for one who decides to sail across the Ocean of Misgivings with doubts in his mind, not unlike the sailors of Santa Maria did in the 15th century when they were still not quite convinced that the earth was round.

Having been accepted by too many obstetricians in the New World, belief in the ritual of reducing head-to-body delivery time and in the myth of "*in utero*" acquired Erb's palsies has become a matter of faith. "Faith can move mountains". Actually, it has already moved one when the ancient fortress of sound obstetric practice in London opened its gate and invited the trans-Atlantic Trojan horse inside its walls.

Lack of supporting evidence does not automatically sink attractive new ideas back into oblivion. More comforting is to think that the missing evidence is hidden somewhere nearby. The alternative would be to admit that well-meaning doctors have deceived themselves when they announced the discovery of a magic formula, capable of solving a distressing medical problem and putting the evil jinn of malpractice claims back into the bottle from where he had escaped. Alas, facts do not always prevail over wishful thinking. It is difficult for doctors who have done what they considered best for their patients to acknowledge that some of their activities were counterproductive. Ignatz Semmelweis was tormented by this thought throughout his life. Some others found easier ways out.

Almost two centuries ago Oliver Wendell Holmes presented a thesis which was important enough to be remembered thousand years from now. He eloquently, logically and correctly explained the cause and patterns of spread of puerperal fever[104]. His lecture included the unwelcome news that doctors who provided care for women in labor unwittingly transferred a deadly disease from one mother to the next. Having given due consideration to his already famous colleague's discovery, Professor Meigs one of the foremost authorities in obstetrics at that time, declared his own opinion. With one single sentence he may have sealed the fate of more women than the number of those whom all obstetricians in America saved from death during his professional lifetime. He also demonstrated that men incapable of seeing the difference between "belief" and "knowledge" could achieve distinguished reputation in medicine: "I prefer to believe"-he said-"that childbed fever is brought about by the will of Providence, which I understand, than that it is caused by an unknown contagion, which I don't"[105].

Footnotes

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