European Journal of Obstetrics and Gynecology 283 (2023) 74–80

Contents lists available at ScienceDirect

European Journal of Obstetrics & Gynecology and Reproductive Biology

journal homepage: www.journals.elsevier.com/european-journal-of-obstetrics-and-gynecology-and-reproductive-biology

Full length article

Risk factors for and consequences of difficult fetal extraction in emergency caesarean section. A retrospective registry-based cohort study

I.L.A. Ammitzbøll [a,d,*], B.R. Andersen [a,b,d], K.H.W. Lange [b,c,d], T. Clausen [a,b,d], E.C.L. Løkkegaard [a,b,d]

[a] Department of Obstetrics and Gynecology, Nordsjællands Hospital, Denmark
[b] Department of Clinical Medicine, University of Copenhagen, Denmark
[c] Department of Anesthesiology, Nordsjællands Hospital, Denmark
[d] Nordsjællands Hospital, 3400 Hillerød, Denmark

ARTICLE INFO

Keywords:
Emergency caesarean section
Difficult fetal extraction
Top-up epidural anesthesia
Impacted fetal head
Neonatal
Maternal

ABSTRACT

Introduction: This study aimed to assess risk factors for difficult fetal extraction in emergency caesarean sections, focusing on top-up epidural anesthesia compared to spinal anesthesia. Additionally, this study addressed consequences of difficult fetal extraction on neonatal and maternal morbidity.

Material and Methods: This retrospective registry-based cohort study included 2,332 of 2,892 emergency caesarean sections performed with local anesthesia during 2010–2017. Main outcomes were analyzed by crude and multiple adjusted logistic regression providing odds ratios.

Results: Difficult fetal extraction was found in 14.9% of emergency caesarean sections.

Risk-factors for difficult fetal extraction included top-up epidural anesthesia (aOR:1.37[95 %CI 1.04–1.81]), high pre-pregnancy BMI (aOR:1.41[95 %CI 1.05–1.89]), deep fetal descent (ischial spine: aOR:2.53[95 %CI 1.89–3.39], pelvic floor: aOR:3.11[95 %CI 1.32–7.33]), and anterior placental position (aOR:1.37[95 %CI 1.06–1.77]). Difficult fetal extraction was associated with increased risk of low umbilical artery pH 7.00–7.09 (aOR:3.50[95 %CI 1.98–6.15]) pH $\leq$ 6.99 (aOR:4.20[95 %CI 1.61–10.91]), five-minute Apgar score $\leq$ 6 (aOR:3.41[95 %CI 1.49–7.83]) and maternal blood loss (501–1,000 ml: aOR:1.65[95 %CI 1.27–2.16], 1,001–1,500 ml: aOR:3.24[95 %CI 2.24–4.67], 1,501–2,000 ml: aOR:3.94[95 %CI 2.24–6.94] and $\geq$ 2001 ml: aOR:2.76[95 %CI 1.12–6.82]).

Conclusion: This study identified four risk factors for difficult fetal extraction in emergency caesarean section: top-up epidural anesthesia, high maternal BMI, deep fetal descent and anterior placental position. Additionally, difficult fetal extraction was associated with poor neonatal and maternal outcomes.

Introduction

Difficult fetal extraction(DFE) during emergency cesarean section (CS) may prolong delivery interval and cause adverse outcomes for mother and child [1–4]. Currently, no universal definition of DFE is described and used consistently.

Several factors can theoretically be associated with DFE. First, type of anesthesia may influence fetal extraction since emergency CSs are performed with either spinal-, top-up epidural- or general anesthesia [5]. Second, oxytocin augmentation used to stimulate contractions during delivery [6] may cause a contracted uterine muscle and DFE. Third, high maternal BMI can lead to poor visualization of the surgical field [7], and has been associated with prolonged incision-to-delivery interval [8].

Fourth, a deeply engaged head in the pelvis is known to cause DFE in emergency CSs [1–4,9]. Furthermore, placental position, rupture of membranes prior to emergency CS, fetal weight and gestational age could also be potential risk factors for DFE. However, neither of these factors have been investigated.

Clinical consequences of DFE on maternal and neonatal morbidity

Abbreviations: DFE, Difficult fetal extraction; CS, Caesarean section; BMI, Body Mass Index; Apgar5, Five-minute Apgar score; ml, milliliters; OR, Odds Ratio; aOR, Adjusted Odds Ratio; g, grams; CI, Confidence Interval.

* Corresponding author at: Department of Obstetrics and Gynecology, Nordsjællands Hospital, 3400 Hillerød, Denmark.
E-mail address: arevad.ammitzboell@gmail.com (I.L.A. Ammitzbøll).

https://doi.org/10.1016/j.ejogrb.2023.02.012
Received 8 December 2022; Received in revised form 9 February 2023; Accepted 13 February 2023
Available online 15 February 2023

have previously been investigated [1–4]. Maternal blood loss is a well-established risk factor for maternal morbidity and mortality [10–12]. Placental position has been associated with higher risk of postpartum haemorrhage [13].

Five-minute Apgar score(Apgar5) is a measure for fetal neurological state at birth, while umbilical artery pH < 7.10 is a predictor for neonatal acidosis [14]. Neonatal acidosis increases the risk for neonatal mortality [15–17] and neonatal morbidity [18–26]. DFE due to an impacted fetal head has in one study been associated with low umbilical artery pH.

The aim of this study is to assess risk factors for DFE in emergency CSs with a focus on the risk associated with top-up epidural anesthesia compared to spinal anesthesia. In addition, we investigate how DFE affects neonatal and maternal morbidity.

Material and methods

Study design

This is a retrospective cohort study of all women who underwent emergency CS at Nordsjællands Hospital, Hillerød, Denmark, between January 1st, 2010 and March 16th, 2017, and their children.

Study population

All women with singleton pregnancies both cephalic and breech presentation who had emergency CSs classified as category 1, 2 or 3 based on urgency, and maximum tolerated time from decision-to-delivery was 15, 30 or 60 min respectively. Emergency CSs with general anesthesia and/or missing information were excluded.

Data sources

The personal identification number of each woman was extracted through an electronic health record system, DocuLive(Cerner-Corporation, USA). Afterwards, all data regarding mother and child were manually collected through medical charts found in the electronic birth journal KMD-Fødejournal, the local surgery registry Orbit and the EPIC health platform Sundhedsplatformen.

Defining difficult fetal extraction

We defined fetal extraction as difficult if extra ordinary measures were used or if DFE was described in the medical record. A fetal extraction was defined as difficult if at least one of the following descriptions were applied in the medical record when describing the extraction: 1) the words “difficult”, “a little difficult” or related synonyms were used, 2) kiwi cup was used for fetal extraction, 3) midwife/assistant pushed the fetal head up through the vagina, 4) use of terbutaline or glyceryl trinitrate or 5) another surgeon was called to assist with fetal extraction [2,27].

Risk factors for difficult fetal extraction in emergency caesarean sections

The following nine potential risk factors for DFE were included in the statistical analysis.

Maternal age; maternal pre-pregnancy BMI; fetal birth weight; gestational age at delivery; fetal pelvic descent recorded as last noted position prior to emergency CS; rupture of membranes prior to emergency CS; oxytocin augmentation; placental location in the uterus recorded as last noted position determined by ultrasound; and type of anesthesia at the start of fetal extraction defined in Tables 1 and 2.

Clinical consequences of difficult fetal extraction

To assess the clinical consequences of DFE, neonatal and maternal

Table 1
Descriptive statistics of the study population at baseline by presence of fetal extraction difficulties.

	Difficult fetal extraction: No n (%) 1984 (85.1)	Difficult fetal extraction: Yes n (%) 348 (14.9)
Maternal age (years)		
≤25	301 (15.2)	51 (14.7)
26–35	1221 (61.5)	231 (66.4)
≥36	462 (23.3)	66 (19.0)
Missing	0 (0.0)	0 (0.0)
Maternal pre-pregnancy BMI (kg/m²)*		
≤18.49	69 (3.5)	7 (2.0)
18.50–24.99	1097 (55.3)	174 (50.0)
25.00–29.99	476 (24.0)	101 (29.0)
30.00–34.99	195 (9.8)	35 (10.1)
35.00–39.99	81 (4.1)	17 (4.9)
≥40.00	29 (1.5)	10 (2.9)
Missing	37 (1.9)	4 (1.2)
Fetal birth weight (gram)		
≤1999	84 (4.2)	12 (3.5)
2000–2499	101 (5.1)	13 (3.7)
2500–2999	222 (11.2)	35 (10.1)
3000–3499	523 (26.4)	80 (23.0)
3500–3999	616 (31.1)	108 (31.0)
≥4000	433 (21.8)	98 (28.2)
Missing	5 (0.3)	2 (0.6)
Gestational age (weeks+days)		
≤31+6	37 (1.9)	4 (1.2)
32–36+6	187 (9.4)	29 (8.3)
37–40+0	687 (34.6)	105 (30.2)
≥40+1	1073 (54.1)	210 (60.3)
Missing	0 (0.0)	0 (0.0)
Fetal descent into the pelvis		
Pelvic entrance	1656 (83.5)	233 (67.0)
Ischial spine	294 (14.8)	103 (29.6)
Pelvic floor	22 (1.1)	9 (2.6)
Missing	12 (0.6)	3 (0.9)
Rupture of membranes prior to fetal extraction		
Yes	1586 (79.9)	303 (87.1)
No	398 (20.1)	45 (12.9)
Missing	0 (0.0)	0 (0.0)
Oxytocin drop prior to fetal extraction		
Yes	1057 (53.3)	230 (66.1)
No	927 (46.7)	118 (33.9)
Missing	0 (0.0)	0 (0.0)
Placental location in the uterus		
Posterior	857 (43.2)	127 (36.5)
Anterior	876 (44.2)	177 (50.9)
Fundus	57 (2.9)	11 (3.2)
Praevia/partial praevia	26 (1.3)	1 (0.3)
Missing	168 (8.5)	32 (9.2)
Type of anesthesia at the start of fetal extraction		
Spinal anesthesia	1386 (69.9)	206 (59.2)
Top-up epidural anesthesia	598 (30.1)	142 (40.8)
Missing	0 (0.0)	0 (0.0)
Five-minute Apgar score[1]		
≤6	39 (2.0)	15 (4.3)

(*continued on next page*)

Table 1 (*continued*)

	Difficult fetal extraction: No n (%) 1984 (85.1)	Difficult fetal extraction: Yes n (%) 348 (14.9)
7–10	1941 (97.8)	333 (95.7)
Missing	4 (0.2)	0 (0.0)
Umbilical artery pH value[1]		
≤6.99	15 (0.8)	8 (2.3)
7.00–7.09	41 (2.1)	22 (6.3)
≥7.10	1582 (79.7)	262 (75.3)
Missing	346 (17.4)	56 (16.9)
Maternal blood loss (ml)[1]		
0–500	1105 (55.7)	127 (36.5)
501–1000	677 (34.1)	136 (39.1)
1001–1500	141 (7.1)	57 (16.4)
1501–2000	41 (2.1)	21 (6.0)
≥2001	19 (1.0)	7 (2.0)
Missing	1 (0.1)	0 (0.0)
Surgical experience[2]		
Junior doctor	1297 (55.1)	204 (58.6)
Obstetrician	718 (30.6)	111 (31.9)
Gynecologist	317 (14.4)	33 (9.5)
Time from skin incision to delivery in minutes[3]		
	Difficult fetal extraction: No n (mean (SD))	Difficult fetal extraction: Yes n (mean (SD))
Emergency grade		
Category 1, 2 and 3	1928 (4.33 (2.79))	338 (7.39 (3.72))
Category 1	50 (2.20 (1.71))	10 (5.30 (1.89))
Category 2	779 (3.78 (2.31))	142 (6.38 (3.29))
Category 3	980 (4.92 (3.02))	175 (8.34 (3.87))

morbidity were evaluated as secondary outcomes.

Maternal morbidity was assessed by measured maternal blood loss and was adjusted for the following confounders [27]: maternal pre-pregnancy BMI; maternal age; maternal parity; maternal diseases; emergency CS indications; induced labor; oxytocin augmentation; and fetal birth weight defined in Table 1 and 4.

Neonatal morbidity was evaluated by umbilical artery pH and Apgar5 score and were both adjusted for the following confounders: placental location and indications for emergency CS defined in Table 1 and 4.

Sensitivity analysis

In the first sensitivity analysis we redefined DFE to accommodate other views of the definition, and we only included instances where: 1) the words “difficult”, “a little difficult” or related synonyms were used, 2) midwife/assistant pushed the fetal head up through the vagina or 3) use of terbutaline or glyceryl trinitrate.

The purpose of the second and third sensitivity analyses was to investigate the stability of the top-up epidural anesthesia as a risk factor for DFE. Hence, in the second sensitivity analysis, we restricted the population in four different ways by including only: A) primiparous women, B) women with no prior CS, C) emergency category 2 CS and D) women with a pre pregnancy BMI between 18.5 and 24.99.

In the third sensitivity analysis, the population was stratified into women with presumed long labors and all other labors based on the indication for emergency CS as: i) “failure to progress in labor” or ii) all other indications.

Table 2
Risk factors for difficult fetal extraction in univariate and adjusted logistic regressions.

Risk factors	Crude OR	[95% CI]	Adjusted OR	[95% CI]
Maternal age (years)				
≤25	0.9	[0.64–1.24]	0.91	[0.63–1.30]
26–35	1	1	1	1
≥36	0.75	[0.56–1.01]	0.81	[0.59–1.11]
Maternal pre-pregnancy BMI (kg/m^2)*				
≤18.49	0.64	[0.29–1.42]	0.56	[0.22–1.44]
18.50–24.99	1	1	1	1
25.00–29.99	1.34	[1.03–1.75]	1.41	[1.05–1.89]
30.00–34.99	1.13	[0.76–1.68]	1.3	[0.85–1.98]
35.00–39.99	1.32	[0.77–2.29]	1.25	[0.69–2.24]
≥40.00	2.17	[1.04–4.54]	1.85	[0.81–4.23]
Fetal birth weight (grams)				
≤1999	0.82	[0.43–1.54]	1.04	[0.38–2.85]
2000–2499	0.73	[0.40–1.36]	0.8	[0.34–1.89]
2500–2999	0.9	[0.60–1.36]	1.11	[0.67–1.85]
3000–3499	0.87	[0.64–1.19]	0.93	[0.66–1.31]
3500–3999	1	1	1	1
≥4000	1.29	[0.96–1.74]	1.21	[0.87–1.68]
Gestational age (weeks+days)				
≤31+6	0.71	[0.25–2.03]	1.11	[0.27–4.55]
32–36+6	1.02	[0.65–1.58]	1.44	[0.75–2.79]
37–40+0	1	1	1	1
≥40+1	1.28	[0.99–1.65]	1	[0.74–1.35]
Fetal descent into the pelvis				
Pelvic entrance	1	1	1	1
Ischial spine	2.49	[1.91–3.24]	2.53	[1.89–3.39]
Pelvic floor	2.91	[1.32–6.40]	3.11	[1.32–7.33]
Rupture of membranes prior to caesarean section				
Yes	1.69	[1.21–2.36]	1.01	[0.65–1.57]
No	1	1	1	1
Oxytocin augmentation				
Yes	1.71	[1.35–2.17]	1.2	[0.88–1.64]
No	1	1	1	1
Placental location in the uterus				
Posterior	1	1	1	1
Anterior	1.36	[1.07–1.75]	1.37	[1.06–1.77]
Fundus	1.3	[0.67–2.55]	1.58	[0.79–3.15]
Praevia/partial praevia	0.26	[0.04–1.93]	0.33	[0.04–2.63]
Type of anesthesia at the start of fetal extraction				
Spinal	1	1	1	1
Top-up epidural	1.6	[1.26–2.02]	1.37	[1.04–1.81]

Statistical methods

Risk factors for DFE and consequences of DFE on neonatal and maternal outcomes as well as sensitivity analyses were explored in crude and multiple adjusted logistic regression analyses providing ORs with 95 % confidence intervals.

All potential risk factors were transformed into categorical variables. The reference group for each risk factor was based on normal distribution within maternal age and based on being the least theoretically plausible for DFE within maternal BMI, gestational age, fetal weight, fetal descent into the pelvis, membrane rupture, oxytocin augmentation,

cervical dilation, and placental position.

We used SPSS software version 25(Statistical Package of Social Sciences) for all statistical analyses.

Ethics statement

The study was reported to the Danish Patient Safety Authority (3–3013-1732/1) and approved. Data was reported to the Danish Data Protection Agency(NOH-2015–040. I-Suite: 04287).

URL: https://stps.dk/.

Results

In total, 2,892 emergency CSs were assessed, of which 560 were excluded for the following reasons: twin births(n = 134), emergency CS performed with general anesthesia(n = 433) or missing information about type of anesthesia(n = 11), resulting in 2,332 participants in descriptive and crude analyses(Table 1). Furthermore, 241 cases were excluded from the main multiple adjusted analysis due to missing information on risk factors included in this study(total n = 2,091).

Risk factors for a difficult fetal extraction

In the multiple adjusted analysis, the risk of DFE remained significantly higher for top-up epidural compared to spinal anesthesia (aOR:1.37[95 %CI 1.04–1.81]); maternal BMI 25.00–29.99(aOR:1.41 [95 %CI 1.05–1.89]) compared to a BMI between 18.5 and 24.99; deeper fetal descent to the ischial spine(aOR:2.53[95 %CI 1.89–3.39]) and pelvic floor(aOR:3.11[95 %CI 1.32–7.33]) compared to the pelvic entrance; and anterior placental position(aOR:1.37[95 %CI 1.06–1.77]) compared to posterior placental location(Table 2).

For results from the crude analyses see Table 2.

Sensitivity analysis

In the first sensitivity analysis with a restricted definition of the outcome(n = 2,332). In this population 12.7 % of the cases had DFE, and the multiple adjusted risk remained increased when administering top-up epidural anesthesia(OR:1.39[95 %CI 1.03–1.86]), with deep fetal descent to the ischial spine(OR:2.73[95 %CI 2.01–3.72]) or pelvic floor (OR:3.88[95 %CI 1.64–9.17]) and in case of anterior placental position (OR:1.43[95 %CI 1.09–1.88]).

In the second sensitivity analysis top-up epidural remained a risk factor for DFE in all four sub-populations(primiparous women(n = 1,411), no prior CS(n = 1,749), emergency category 2 CS(n = 950) and pre-pregnancy normal weight(n = 1,271)) in the crude analyses and showed tendencies in the multiple adjusted analyses. Similar patterns were found for maternal BMI, fetal descent and placental position (Table 3).

In the third sensitivity analysis, top-up epidural was associated with higher risk of DFE(aOR 1.53[95 %CI 1.07–2.20]) in the sub-group where emergency CSs were performed on all other indications than "failure to progress in labor"(n = 1,271), and in total 13.2 % of the emergency CS had DFE.

The risk did not significantly increase in the sub-group of emergency CSs performed on the indication "failure to progress in labor"(aOR:1.23 [95 %CI 0.85–1.79](n = 922)). This subgroup was, however, the one with the highest incidence of DFE at 18.3 %.

Clinical consequences of difficult fetal extraction

DFE was associated with increased risk of low umbilical artery pH, low Apgar5 and maternal blood loss. This was found in both crude and multiple adjusted analyses (Table 4).

The multiple adjusted risk of an umbilical artery pH of 7–7.09 was 3.47[95 %CI 1.97–6.12], whereas the risk of an umbilical artery pH <

Table 3
Second sensitivity analyses exploring risk factors for difficult fetal extraction in four different populations.

	Delivery difficulties n (%)		Crude OR (95% CI)	Adjusted OR (95% CI)
Including only primiparous women n = 1411	Yes (n = 247)	No (n = 1164)	n = 1411	n = 1256
Maternal pre-pregnancy BMI (kg/m²)				
≤18.49	4 (1.6)	43 (3.7)	0.54 (0.19–1.53)	0.31 (0.07–1.33)
18.50–24.99	114 (46.2)	662 (56.9)	1	1
25.00–29.99	68 (27.5)	275 (23.6)	1.44 (1.03–2.00)	1.42 (0.99–2.05)
30.00–34.99	26 (10.5)	108 (9.3)	1.40 (0.87–2.24)	1.48 (0.89–2.48)
35.00–39.99	10 (4.1)	54 (4.6)	1.08 (0.53–2.17)	0.89 (0.41–1.93)
≥40.00	5 (2.0)	22 (1.9)	1.32 (0.49–3.56)	1.40 (0.50–3.91)
Missing	0 (0.0)	0 (0.0)		
Fetal descent into the pelvis				
Pelvic entrance	142 (57.5)	927 (79.6)	1	1
Ischial spine	80 (32.4)	221 (19.0)	2.39 (1.75–3.27)	2.52 (1.77–3.58)
Pelvic floor	8 (3.2)	16 (1.4)	3.61 (1.39–7.87)	3.79 (1.44–10.0)
Missing	17 (6.9)	0 (0.0)		
Placental location in the uterus				
Posterior	79 (32.0)	522 (86.9)	1	1
Anterior	120 (48.6)	504 (80.8)	1.57 (1.16–2.14)	1.59 (1.15–2.20)
Fundus	5 (2.0)	35 (87.5)	0.94 (0.36–2.48)	1.29 (0.47–3.54)
Praevia/partial praevia	0 (0.0)	9 (100)	-	-
Missing	43 (17.4)	64 (5.5)		
Type of anesthesia at time of fetal extraction				
Epidural	114 (46.2)	418 (80.5)	1.45 (1.09–1.93)	1.34 (0.96–1.88)
Spinal	133 (53.8)	746 (85.6)	1	1
Missing	0 (0.0)	0 (0.0)		
Including only women with no prior caesarean section n = 1749	Delivery difficulties n (%) Yes (n = 260)	No (n = 1489)	Crude OR (95% CI) n = 1749	Adjusted OR (95% CI) n = 1561
Maternal pre-pregnancy BMI (kg/m²)				
≤18.49	6 (2.3)	51 (3.4)	0.75 (0.32–1.79)	0.60 (0.20–1.75)
18.50–24.99	129 (49.6)	826 (55.5)	1	1
25.00–29.99	74 (28.5)	358 (24.0)	1.32 (0.97–1.81)	1.35 (0.96–1.91)
30.00–34.99	29 (11.2)	142 (9.5)	1.31 (0.84–2.03)	1.40 (0.87–2.26)
35.00–39.99	12 (4.6)	63 (4.2)	1.22 (0.64–2.32)	1.06 (0.53–2.15)
≥40.00	7 (2.7)	25 (16.8)	1.79 (0.76–4.23)	1.64 (0.64–4.21)

(continued on next page)

Table 3 (*continued*)

	Delivery difficulties n (%)		Crude OR (95% CI)	Adjusted OR (95% CI)
Including only primiparous women n = 1411	Yes (n = 247)	No (n = 1164)	n = 1411	n = 1256
Missing	3 (1.2)	24 (1.6)		
Fetal descent into the pelvis				
Pelvic entrance	164 (63.1)	1204 (80.9)	1	1
Ischial spine	86 (33.1)	256 (17.2)	2.47 (1.84–3.31)	2.51 (1.80–3.50)
Pelvic floor	8 (3.1)	18 (1.2)	3.26 (1.40–7.62)	3.31 (1.30–8.46)
Missing	2 (0.8)	11 (0.7)		
Placental location in the uterus				
Posterior	88 (33.8)	649 (43.6)	1	1
Anterior	138 (53.1)	645 (43.3)	1.58 (1.18–2.12)	1.62 (1.20–2.19)
Fundus	8 (3.1)	42 (2.8)	1.41 (0.64–3.09)	1.96 (0.87–4.44)
Praevia/partial praevia	0 (0.0)	20 (1.3)	-	-
Missing	26 (0.1)	143 (9.6)		
Type of anesthesia at time of fetal extraction				
Epidural	107 (41.2)	489 (82.0)	1.43 (1.09–1.87)	1.25 (0.91–1.72)
Spinal	153 (58.8)	1000 (86.7)	1	1
Missing	0 (0.0)	0 (0.0)		
Including only emergency category 2 caesarean sections n = 950	Delivery difficulties n (%) Yes (n = 146)	No (n = 804)	Crude OR (95% CI) n = 950	Adjusted OR (95% CI) n = 878
Maternal pre-pregnancy BMI (kg/m^2)				
≤18.49	2 (1.4)	28 (3.5)	0.42 (0.97–1.78)	0.46 (0.10–2.06)
18.50–24.99	77 (52.7)	447 (55.6)	1	1
25.00–29.99	46 (31.5)	198 (24.6)	1.35 (0.90–2.06)	1.54 (0.99–2.41)
30.00–34.99	9 (6.2)	73 (9.1)	0.72 (0.34–1.49)	0.94 (0.44–2.03)
35.00–39.99	7 (4.8)	26 (3.2)	1.56 (0.66–3.73)	1.42 (0.53–3.84)
≥40.00	4 (2.7)	10 (1.2)	2.32 (0.71–7.59)	1.86 (0.38 -9.10)
Missing	1 (0.7)	22 (2.7)		
Fetal descent into the pelvis				
Pelvic entrance	84 (57.5)	631 (78.5)	1	1
Ischial spine	54 (37.0)	153 (19.0)	2.65 (1.80–3.90)	2.87 (1.85–4.44)
Pelvic floor	5 (3.4)	14 (1.7)	2.68 (0.94–7.64)	4.06 (1.30–12.70)
Missing	3 (2.1)	6 (0.7)		
Placental location in the uterus				
Posterior	55 (37.7)	340 (42.3)	1	1
Anterior	76 (52.1)	367 (45.6)	1.28 (0.89 -1.87)	1.41 (0.94–2.11)
Fundus	5 (3.4)	21 (2.6)	1.47 (0.53–4.07)	1.64 (0.57–4.76)
Praevia/partial praevia	0 (0.0)	7 (0.9)	-	-
Missing	10 (6.8)	69 (7.5)		
Type of anesthesia at time of fetal extraction				
Epidural	68 (46.6)	295 (36.7)	1.50 (1.05–2.15)	1.40 (0.92–2.13)
Spinal	78 (53.4)	509 (63.3)	1	1
Missing	0 (0.0)	0 (0.0)		
Including only maternal pre pregnancy BMI (kg/m^2) between 18.5–24.99* n = 1271	Delivery difficulties n (%) Yes (n = 174)	No (n = 1097)	Crude OR (95% CI) n = 1271	Adjusted OR (95% CI) n = 878
Fetal descent into the pelvis				
Pelvic entrance	112 (64.4)	899 (82.0)	1	1
Ischial spine	57 (32.8)	179 (16.3)	2.55 (1.79–3.64)	2.58 (1.73–3.84)
Pelvic floor	4 (2.3)	16 (1.5)	2.00 (0.66–6.09)	2.27 (0.73–7.16)
Missing	1 (0.6)	3 (0.3)		
Placental location in the uterus				
Posterior	64 (36.8)	486 (44.3)	1	1
Anterior	86 (49.4)	482 (44.0)	1.35 (0.96–1.92)	1.35 (0.94–1.94)
Fundus	6 (3.4)	34 (3.1)	1.34 (0.54–3.16)	1.49 (0.58–3.84)
Praevia/partial praevia	0 (0.0)	11 (1.0)	-	-
Missing	18 (10.3)	84 (7.7)		
Type of anesthesia at time of fetal extraction				
Epidural	71 (40.8)	322 (29.4)	1.66 (1.19–2.31)	1.39 (0.94–2.04)
Spinal	103 (59.2)	775 (70.6)	1	1
Missing	0 (0.0)	0 (0.0)		

[1] Factors collected after fetal extraction. Total population n = 2,332.
[2] "Trainee" defined as all surgeons who were not yet fully trained specialists.
[3] Values under 0 or above 30 excluded
*BMI = Body Mass Index.
Number of excluded cases due to missing information: maternal age = 1, maternal pre-pregnancy BMI = 41, fetal birth weight = 7, gestational age = 0, fetal descent into the pelvis = 15, rupture of membranes prior to fetal extraction = 0, oxytocin drop prior to fetal extraction = 0, placental location = 200, five-minute Apgar score = 4, umbilical artery pH value = 402.

7.00 was 4.18[95 %CI 1.61–10.88], both compared to a pH ≥ 7.10(n = 1,930).

The multiple adjusted risk of an Apgar5 score < 7 compared to a score ≥ 7 was 2.44[95 %CI 1.26–4.73](n = 2,328).

Women who had an emergency CS with DFE had increased risk of blood loss of 501–1,000 ml, 1,001–1,500 ml, 1,501–2,000 ml and ≥ 2,001 ml, respectively with ORs of 1.65[95 %CI 1.27–2.16], 3.24[95 %

Table 4
Clinical consequences of difficult fetal extraction: three maternal and neonatal outcomes after difficult fetal extraction from binary logistic and multinomial regression.

	Crude OR (95%CI)	Adjusted OR (95%CI)
Umbilical artery pH value[a]		
≤6.99	3.22 (1.35–7.67)	4.18 (1.61–10.88)
7.00–7.09	3.24 (1.90–5.53)	3.47 (1.97–6.12)
≥7.10	1	1
Five-minute Apgar score[a]		
≤6	2.24 (1.22–4.12)	2.44 (1.26–4.73)
7–10	1	1
Maternal blood loss (ml)[b]		
0–500	1	1
501–1000	1.75 (1.35–2.27)	1.65 (1.27–2.16)
1001–1500	3.52 (2.46–5.03)	3.24 (2.24–4.67)
1501–2000	4.46 (2.55–7.78)	3.94 (2.24–6.94)
≥2001	3.21 (1.32–7.77)	2.76 (1.12–6.82)

2332 cases were included in the crude analysis.
Number of excluded cases due to missing information in the adjusted logistic regression: 241.
In the adjusted logistic regression, all nine risk factors listed in this table, was included.
* BMI = Body Mass Index.

CI 2.24–4.67], 3.94[95 %CI 2.24–6.94] and 2.76[95 %CI 1.12–6.82], respectively(n = 2,285).

Discussion

DFE in emergency CS is a fairly common, known and feared obstetric emergency situation.

We identified four different risk factors for DFE: top-up epidural anesthesia, high maternal pre-pregnancy BMI, deep fetal descent and anterior placental position. Furthermore, we found association between and low umbilical artery pH, low Apgar5 and maternal blood loss.

Our finding of top-up epidurals as a risk factor for DFE is new, though theoretically plausible. Studies have found that even though the time interval from arrival at the operating room to incision is shorter using top-up epidural anesthesia [8,28], it has a less dense motor block [28–30]. Tight abdominal muscles might cause difficulties delivering the fetus, though this has not been explored. These studies used the same local anesthetics and quantity as recommended in the Danish national guideline [5]. The finding is of clinical relevance as using spinal anesthesia potentially can eliminate insufficient motor block and consequently lower the risk of DFE.

We adjusted for theoretically and biologically plausible potential risk factors, except for duration of active labor. Though a 2005 Cochrane review found second stage of labor to be prolonged with a median of only 14 min [31], the epidural analgesia could indirectly cause an impacted fetal head and thus DFE, leading the cause to be epidural analgesia and not top-up epidural anesthesia.

However, in the third sensitivity analysis, an increased risk of DFE when using top-up epidural anesthesia was still present when excluding "long labors" defined by CS indications "failure to progress in labor". Based on our analyses, it is likely that our theory of weaker motor blockage in top-up epidural anesthesia, is causing DFE.

We found maternal pre-pregnancy BMI between 25 and 29.99 to be a risk factor for DFE, and a BMI above 29.99 showed tendencies. We did not identify any prior studies reporting pre-pregnancy BMI as a risk factor for DFE.

A deeply engaged head in the pelvis as a risk factor for DFE have been explored [2–4,9]. These studies only included CS with a deeply engaged head and focused solely on different methods of fetal extraction. The strategies include reverse breech extraction, Patwardhan and the push method. In our study, we aimed to assess whether the depth of fetal descent into the pelvis was a risk factor. As expected, we found the risk of DFE increased the more descended the fetal head was. One other study finds fetal descent to be a risk factor for a deeply engaged head and thus DFE [9].

The anterior placental position was also found to be a risk factor for DFE. No prior studies researching placental location as a risk factor for DFE were found. Although it is impossible to alter the placental position, this finding suggests knowledge of the placental position prior to emergency CS could be useful for the surgeon to be prepared for a potentially DFE.

Prior studies have found associations between maternal and neonatal morbidity and caesarean delivery of a deeply engaged head [1–3,9,32]. We found DFE to be associated with an increased risk of maternal morbidity in terms of maternal blood loss, and increased risk of neonatal morbidity reflected in lower Apgar5 scores and lower umbilical artery pH. These findings are of clinical relevance and stress the importance of future studies on DFE in order to inform the development of evidence-based guidelines on this matter.

Strengths and limitations

This study is the first to explore risk factors for DFE in emergency caesarean sections. Selection bias was reduced, as all women undergoing emergency CS were included in the study. Women included in this study live in North Zealand, which is one specific region of Denmark and the external validity of the findings is not known.

Overreporting DFE is very unlikely since observations were made based on a clinical setting where personnel and patients were not aware, they were being observed. Therefore, no information bias on the risk factors for DFE are expected, specifically regarding top-up epidural anesthesia compared to spinal anesthesia. Whereas concerning consequences from DFE information bias may occur as surgeons might be more likely to describe details in CS with surgical and neonatal complications. We acknowledge that junior doctors might report DFE more often than senior doctors. However junior doctors and obstetricians reported DFE almost equally as frequent with 15.7 % and 15.5 % respectively, indicating that junior doctors at North Zealand hospital are not more likely to report DFE extraction than obstetricians, therefor we did not include surgical experience as a risk factor.

This study is the first to suggest a definition of DFE based on taking extraordinary measures in regard to the fetal extraction. Theoretically DFE would take longer time than an emergency CS without DFE, and in our descriptive statistics it is easy to see that no matter the emergency category the mean time from skin incision to delivery was almost twice as long as long in the emergency CS we defined as having DFE. This indicates a strong validity in our definition of DFE. However, a universal consensus of the definition of DFE is needed.

Almost all data was collected manually, and even though the data was corrected for typing errors, there are bound to be some mistakes in the data collected. Nonetheless, it is a non-differential misclassification.

An important strength is that all the sensitivity analyses support the findings from the primary analyses.

Finally, our large sample size is considered one of the main strengths.

We recommend prospective future studies with a predefined definition of DFE, including the same risk factors as well as a measurement of the depth of the anesthesia.

Conclusion

DFE in emergency CS was associated with four risk factors: top-up epidural anesthesia, elevated maternal BMI, deep fetal descent to the ischial spine and pelvic floor, and anterior placental position.

Further, DFE was associated with poor neonatal and maternal outcomes defined as low umbilical cord pH, low Apgar5 and maternal blood loss.

There is a need for additional research on this obstetric emergency situation and fetal extraction difficulties need to be formally categorized and coded.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

We have no acknowledgements.

References

[1] Rada MP, Ciortea R, Măluțan AM, Prundeanu I, Doumouchtsis SK, Bucuri CE, et al. Maternal and neonatal outcomes associated with delivery techniques for impacted fetal head at cesarean section: a systematic review and meta-analysis. J Perinat Med 2022;50(4):446–56.
[2] Waterfall H, Grivell RM, Dodd JM. Techniques for assisting difficult delivery at caesarean section. Cochrane Pregnancy and Childbirth Group, editor. Cochrane Database Syst Rev [Internet]. 2016 Jan 31 [cited 2022 Nov 22];2016(1). Available from: http://doi.wiley.com/10.1002/14651858.CD004944.pub3.
[3] Delivery of the impacted head of the fetus at caesarean section after prolonged obstructed labour: a randomised comparative study of two methods. J Obstet Gynaecol. 2002 Jan;22(4):375–8.
[4] Berhan Y, Berhan A. A meta-analysis of reverse breech extraction to deliver a deeply impacted head during cesarean delivery. Int J Gynecol Obstet 2014;124(2):99–105.
[5] OBSTETRISK ANÆSTESIUDVALG, DASAIM. Anæstesi til kejsersnit [Internet]. 2019. Available from: http://www.dasaim.dk/wp-content/uploads/2019/10/Anæstesi-til-kejsersnit-2019.pdf.
[6] Nabhan A, Boulvain M. Augmentation of labour. Best Pract Res Clin Obstet Gynaecol 2020;67:80–9.
[7] Waring GJ, Shawer S, Hinshaw K. The use of O-ring retractors at Caesarean section: a systematic review and meta analysis. Eur J Obstet Gynecol Reprod Biol 2018;228:209–14.
[8] Rossouw JN, Hall D, Harvey J. Time between skin incision and delivery during cesarean. Int J Gynecol Obstet 2013;121(1):82–5.
[9] Cornthwaite K, Draycott T, Bahl R, Hotton E, Winter C, Lenguerrand E. Impacted fetal head: a retrospective cohort study of emergency caesarean section. Eur J Obstet Gynecol Reprod Biol 2021;261:85–91.
[10] Khan KS, Wojdyla D, Say L, Gülmezoglu AM, Van Look PF. WHO analysis of causes of maternal death: a systematic review. Lancet 2006;367(9516):1066–74.
[11] Creanga AA, Berg CJ, Syverson C, Seed K, Bruce FC, Callaghan WM. Pregnancy-Related Mortality in the United States, 2006–2010. Obstet Gynecol 2015;125(1):5–12.
[12] Grobman WA, Bailit JL, Rice MM, Wapner RJ, Reddy UM, Varner MW, et al. Frequency of and factors associated with severe maternal morbidity. Obstet Gynecol 2014;123(4):804–10.
[13] Torricelli M, Vannuccini S, Moncini I, Cannoni A, Voltolini C, Conti N, et al. Anterior placental location influences onset and progress of labor and postpartum outcome. Placenta 2015;36(4):463–6.
[14] Andersen KS, Bach D, Greiber I, Frandsen C, Hvidman L, Karstensen S, et al. Fosterovervågning under fødslen(II) – Metoder [Internet]. Available from: Dansk Selskab for Obstetrik og Gynækologi 2022. https://static1.squarespace.com/static/5467abcce4b056d72594db79/t/5c84e7be8165f5cb5fb3e309/1552213956671/Fosterovervågningunderfødsel.pdf.
[15] Goldaber KG, Gilstrap LC, Leveno KJ, Dax JS, McIntire DD. Pathologic fetal acidemia. Obstet Gynecol 1991;78(6):1103–7.
[16] Lavrijsen SW, Uiterwaal CSPM, Stigter RH, de Vries LS, Visser GHA, Groenendaal F. Severe umbilical cord acidemia and neurological outcome in preterm and full-term neonates. Neonatology 2005;88(1):27–34.
[17] Yudkin PL, Johnson A, Clover LM, Murphy KW. Clustering of perinatal markers of birth asphyxia and outcome at age five years. BJOG Int J Obstet Gynaecol 1994;101(9):774–81.
[18] D. Engle W, R. Laptook A, M. Perlman J. Acute changes in arterial carbon dioxide tension and acid–base status and early neurologic characteristics in term infants following perinatal asphyxia. Resuscitation. 1999 Sep;42(1):11–7.
[19] Gilstrap LC, Leveno KJ, Burris J, Lynne Williams M, Little BB. Diagnosis of birth asphyxia on the basis of fetal pH, Apgar score, and newborn cerebral dysfunction. Am J Obstet Gynecol 1989;161(3):825–30.
[20] González de Dios J, Moya M, Carratalá F. Neurological evolution of asphyctic full-term newborns with severe umbilical acidosis (pHUA <7.00). Rev Neurol 2000;31(2):107–13.
[21] Casey BM, Goldaber KG, McIntire DD, Leveno KJ. Outcomes among term infants when two-hour postnatal pH is compared with pH at delivery. Am J Obstet Gynecol 2001;184(3):447–50.
[22] Yeh P, Emary K, Impey L. The relationship between umbilical cord arterial pH and serious adverse neonatal outcome: analysis of 51 519 consecutive validated samples: umbilical cord arterial pH and serious neonatal outcome. BJOG Int J Obstet Gynaecol 2012;119(7):824–31.
[23] Sabol BA, Caughey AB. Acidemia in neonates with a 5-minute Apgar score of 7 or greater – What are the outcomes? Am J Obstet Gynecol 2016;215(4):486.e1–6.
[24] Goodwin TM, Belai I, Hernandez P, Durand M, Paul RH. Asphyxial complications in the term newborn with severe umbilical acidemia. Am J Obstet Gynecol 1992;167(6):1506–12.
[25] Wiberg N, Källén K, Herbst A, Olofsson P. Relation between umbilical cord blood pH, base deficit, lactate, 5-minute Apgar score and development of hypoxic ischemic encephalopathy. Acta Obstet Gynecol Scand 2010;89(10):1263–9.
[26] Ingemarsson I, Herbst A, Thorngren-Jerneck K. Long term outcome after umbilical artery acidaemia at term birth: influence of gender and duration of fetal heart rate abnormalities. BJOG Int J Obstet Gynaecol 1997;104(10):1123–7.
[27] Bødker B, Eriksen L, Hvidman L, Nielsen BB, Sørensen B, Sørensen JL. Postpartum blødning Forebyggelse og håndtering [Internet]. Available from: Dansk Selskab for Obstetrik og Gynækologi 2017. https://static1.squarespace.com/static/5467abcce4b056d72594db79/t/614deb9a930110495a0b706d/1632496549362/Postpartum%2Bblødning%2B2019.%2BRev%2Bfotografier.pdf.
[28] Yoon HJ, Do SH, Yun YJ. Comparing epidural surgical anesthesia and spinal anesthesia following epidural labor analgesia for intrapartum cesarean section: a prospective randomized controlled trial. Korean J Anesthesiol 2017;70(4):412.
[29] Lam DTC, Ngan Kee WD, Khaw KS. Extension of epidural blockade in labour for emergency Caesarean section using 2% lidocaine with epinephrine and fentanyl, with or without alkalinisation*: Forum. Anaesthesia 2001;56(8):777–98.
[30] Choi J, Germond L, Santos AC. Obstetric Regional Anesthesia [Internet]. NYSORA; Available from: https://www.nysora.com/topics/sub-specialties/obstetric/obstetric-regional-anesthesia/.
[31] Anim-Somuah M, Smyth RM, Cyna AM, Cuthbert A. Epidural versus non-epidural or no analgesia for pain management in labour. Cochrane Pregnancy and Childbirth Group, editor. Cochrane Database Syst Rev [Internet]. 2018 May 21 [cited 2022 Nov 22];2018(5). Available from: http://doi.wiley.com/10.1002/14651858.CD000331.pub4.
[32] Lenz F, Kimmich N, Zimmermann R, Kreft M. Maternal and neonatal outcome of reverse breech extraction of an impacted fetal head during caesarean section in advanced stage of labour: a retrospective cohort study. BMC Pregn Childbirth 2019;19(1):98.