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Escalating caesarean deliveries and the impact on subsequent preterm birth

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ABSTRACT

The rate of caesarean section, including those performed in-labour, is on the rise. Worldwide 1 in 5 women are delivering by caesarean section. Emerging evidence has demonstrated an association between in-labour caesarean section and mid-trimester loss (delivery between 14 and 24 weeks gestation) as well as spontaneous preterm birth, (delivery before 37 weeks' gestation). This problem is more likely to recur in subsequent pregnancies and is difficult to treat with evidence suggesting that transvaginal cerclage may be a less efficacious preventative measure in women with a short cervix and previous in-labour caesarean section. This review explores the scope of the issue including the evidence for in-labour caesarean section as a risk factor for preterm birth and the possible underlying mechanism. It will discuss management strategies, as well as highlighting areas where further research is required.

1. Introduction

Approximately 10 % of all babies are born preterm worldwide, before 37 weeks' completed gestation [1]. It is the biggest cause of neonatal and infant mortality worldwide. Survivors of preterm delivery have an increased risk of short-term morbidity including intraventricular haemorrhage and necrotising enterocolitis as well as long-term sequalae including chronic lung disease, cerebral palsy and developmental delay [1,2]. Not only does it have significant repercussions for individuals and their families, but the economic cost to society is also considerable accounting for £ 2.95 billion in England and Wales alone every year [3].

The aetiology of preterm birth is multi-factorial, and risk factors include previous spontaneous preterm birth or mid-trimester loss, cervical surgery, uterine anomalies, and multiple pregnancies. Since 2015, emerging evidence has demonstrated that caesarean section performed at full dilatation is associated with an increased risk of spontaneous preterm birth (sPTB) and mid-trimester loss [4–7]. Further studies have demonstrated that in fact all in-labour caesarean sections (CS) confer an increased risk, and that the rates of recurrent sPTB and mid-trimester loss are higher in this cohort of women [8–12]. Although term deliveries are usually considered a 'protective' factor for preterm delivery, this protective effect is not seen for women who had term caesarean sections in labour [13]. Moreover, treating sPTB following in-labour CS has proven clinically challenging, as transvaginal cerclage may be less effective in these women [13].

The underlying mechanism, for the increased risk of preterm birth following an in-labour CS, is not clear but one hypothesis is damage to the cervical tissue at the time of CS. This damage may be caused by lower segment incisions inadvertently made into cervical tissue, or by traumatic extensions from the lower segment incision [14]. This is more likely with an in-labour or full dilatation caesarean section when the anatomy is more difficult to delineate as the cervix effaces, becomes continuous with the uterine lower segment and is drawn up over the presenting part [15]. With the rising rates of CS globally this is a clinical dilemma with increasing relevance [16]. This paper will outline the issue and highlight key areas to explore in the future.

2. Increasing rates of CS globally

CS is an essential and life-saving surgical procedure when maternal and fetal complications arise during pregnancy and labour, however, the implications for future pregnancies are being increasingly recognised and significant associations include abnormal placentation, ectopic pregnancy and stillbirth[17]. With the rising rates of CS globally, this will lead to a surge in higher risk pregnancies in the future. Indeed, from 1990 to 2014 national data from 154 countries indicated there was an absolute increase in the number of CS performed by 12.4 % from 6.7 %

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to 19.1 [16]. One in five women are now delivered by CS worldwide[16]

In England, one in three women are delivered by CS, reflecting a trend seen across many similar countries. Of all deliveries in the UK, 23 % are performed as an emergency CS and 6 % of these are at full dilatation [18,19]. The number of in-labour, and full dilatation caesarean section has been shown to be increasing across maternity units [19–21]. The reasons for this are multifactorial and changes in professional training and practice, as well as social and cultural expectations are contributory factors to this trend [22].

Increased rates of CS performed in-labour have been associated with a decline in experience and skills in performing instrumental deliveries, especially in settings where there is little training and supervision [15, 22]. This is compounded by the fear of litigation [22]. Maternity claims represent the highest value and second highest number of clinical negligence claims reported to the NHS Litigation Authority [23]. Recent investigations into UK Maternity services, Ockenden and Kirkup, focus on the need to provide safe care to mothers and babies, rather than prioritising 'normal birth' [24,25]. The lessons learnt from these investigations may further contribute to an acute and immediate increase in the number of CS, however the full impact of these reports has yet to be shown.

Moreover, the decision for CS may be patient driven. CS is perceived by the public as a procedure which is safer for the mother and the baby [16,22]. Although maternal request CS relates more to elective CS, some women may prefer a CS in labour over an assisted vaginal delivery.

The focus should be on avoiding unnecessary CS, particularly in-labour and at full dilatation, where appropriate. There are several interventions which can help prevent the first caesarean section, including continuous support in labour, the use of a partogram with a 4-hour action line and involvement of a consultant obstetrician in delivery decision making [26]. Moreover, increased training of junior obstetricians in instrumental deliveries and consultant presence at these deliveries may minimise the need for CS at full dilatation [22]. Finally, if CS is required at advanced dilatation, anticipation and management of complications should be implemented, for example, through use of medical devices such as the fetal pillow or Tydeman Tube [15,27].

3. Evidence for association between caesarean section and preterm birth

An association between CS and the risk of sPTB and mid-trimester loss in subsequent pregnancies has been demonstrated, with initial studies reporting the link in association with previous full dilatation CS. A retrospective cohort analysis by Levine et al. demonstrated a 6-fold increase in sPTB in a full dilatation CS compared to a first stage CS [4].

Further work by Wood et al. showed an increased risk of sPTB < 32

Table 1
Evidence regarding risk of sPTB at < 37 weeks of gestation following Full Dilatation Caesarean Section.

	Population	Study design	Previous vaginal delivery	Previous CS	Relative risk preterm birth	Confidence interval	P-value
Levine et al. (2015)	887 women with two consecutive deliveries at the University Hospital of Pennyslvania, USA 2005–2010	Secondary analysis of retrospective cohort study	7.8 %; 56/721 (all vaginal deliveries)	13.5 %; 5/37 (FDCS)	1.73	0.77–7.43	0.20
Watson et al. (2017)	66 women with a subsequent pregnancy following a sPTB or MTL after a term delivery at two tertiary hospitals London, UK 2012–2016	Case-control study comparing outcomes in women with vaginal delivery and full dilation CS in index pregnancy, followed by sPTB or MTL	18.9 %; 7/37 (all vaginal deliveries)	55.2 %; 16/29 (FDCS)	2.91	1.36–6.13	< 0.005
Wood et al. (2017)	189 021 matched pairs of first and second birth in Alberta, Canada 1992–2014	Retrospective cohort study from Alberta Perinatal Health program database	3.3 %; 4843/144947 (operative and spontaneous vaginal delivery)	3.4 %; 457/8607 (FDCS)	1.58	1.44–1.74	< 0.0001
Cong et al. (2018)	19 099 women with two consecutive pregnancies delivered at Royal Prince Alfred Hospital Sydney, Australia 1989–2015	Retrospective cohort study	1.9 %; 304/15394 (operative and spontaneous vaginal delivery)	3.8 %; 20/533 (FDCS)	1.90	1.21–2.96	0.004
Wang et al. (2020)	106 342 women with two consecutive deliveries in three maternity hospitals Sydney, Australia 2006–2017	Retrospective cohort study comparing mid-cavity instrumental and full dilatation CS	2.0 %; 17/863 (mid-cavity instrumental)	4.3 %; 18/419 (FDCS)	2.18	1.14–4.19	0.023
Liu et al. (2021)	821 women with two consecutive singleton deliveries at a tertiary centre in Brisbane, Australia 2014–2017	Retrospective cohort study	1.8 %; 11/614 (operative and spontaneous vaginal delivery)	3.8 %; 1/26 (FDCS)	2.14	0.28–16.0	0.45
Kleinstern et al. (2022)	13 958 women with first two consecutive singleton birth and first birth at term tertiary centre in Israel 2007–2019	Retrospective cohort study investigating length of second stage and mode of delivery	2.8 %; 302/10852 (operative and spontaneous vaginal delivery)	4.8 %; 25/526 (FDCS)	1.71	1.15–2.54	0.009
Woolner et al. (2023)	30,253 women with two consecutive dleiveries in Abdereen, Scotland 1976–2017	Retrospective cohort study	2.3 % 568/24827 (operative, spontaneous vaginal delivery, CS – elective and first stage of labour)	5.3 % 48/900 (FDCS)	2.33	1.74–3.10	< 0.0001

Table 2 Summary of studies assessing risk of preterm birth < 37 following full dilatation caesarean section; sPTB – spontaneous preterm birth, MTL – mid-trimester loss, CS – caesarean section; FDCS – full dilatation caesarean section

weeks in women with prior full dilatation, with an odds ratio (OR) of 2.44 (95 % confidence interval [CI] 1.91–3.10). There was no effect seen with a history of operative vaginal delivery, CS before labour or CS in the first stage of labour [5]. The evidence demonstrating the association between full dilatation CS and sPTB has grown with multiple additional retrospective studies [6,7,28–31]. See Table 1 for a summary of key studies.

Subsequent work has illustrated that CS itself, not just at full dilatation, is associated with an increased risk. A secondary analysis of data collected from the WHO Multi-Country Survey on Maternity and Child Health, in 359 health centres across 29 countries, demonstrated women with a previous CS were at a small but significant increased risk of sPTB in a subsequent pregnancy as compared to women without a previous CS, adjusted odds ratio (aOR) 1.04 (95 % CI 1.01–1.04)[8]. A Dutch cohort study also demonstrated an increased risk of sPTB in the second pregnancy of women with a previous term CS compared to those with a previous vaginal delivery aOR 1.14 (95 % CI 1.07–1.21)[9]. Although this data reflects an association between all CS and subsequent sPTB, it is likely to be driven by women having in-labour CS later at a more advanced dilatation. See Table 2 for a summary of key studies.

Most worrying is the high risk of a recurrent sPTB in this group of women. A study by Watson et al. demonstrated that absolute risk of recurrent sPTB in women with a previous full dilatation caesarean of 28 % (95 % CI 7–49 %) [32]. Another study, by Suff et al., found that the relative risk (RR) of recurrent sPTB at < 37 weeks' gestation is 2.7 (95 % CI 1.87–3.87) for all emergency CS and 3.1 (95 % CI 1.90–4.60) for full dilatation CS when compared to women with a prior sPTB and no previous emergency CS[12]. This risk further increases when including mid-trimester loss, with 25.4 % delivering at < 24 weeks of gestation (RR 5.65, 95 % CI 2.60–12.00)[12]. Overall, the risk or recurrence of sPTB in women with a history of in-labour is over 50 %, considerably higher than other high-risk groups[12].

Studies have demonstrated conflicting results when assessing the length of the second stage of labour and the risk of sPTB in future pregnancy. Levine et al. found, in a cohort of 757 women, that there was no association between the length of second stage in a previous term vaginal or caesarean delivery and subsequent sPTB aOR 0.83 (95 % CI 0.58–1.20) [33]. This finding was replicated by by Liu et al. [7]. However other studies suggest that a prolonged second stage may be a risk factor for mid-trimester loss and preterm birth [31,34]. Kleinstern et al. describe that the prolonged second stage was not associated with subsequent sPTB in those who delivered by spontaneous and operative vaginal delivery, however was related in those who delivered by caesarean section, aOR 3.40 (95 % CI 1.94–5.94; $p < 0.001$). Further work should be done to explore the relationship between duration of second stage, mode of delivery and subsequent sPTB.

Moreover, the current evidence is largely based upon sub-group analysis of retrospective studies, future work needs to focus on larger cohorts of prospectively collected data. The CRAFT study, due to report, is a prospective observational study which aims to determine the incidence of mid-trimester loss and sPTB in women with a previous in-labour CS and stratify according to cervical dilatation at time of CS [35]

Table 2
Evidence regarding risk of sPTB at < 37 weeks of gestation following caesarean section at any stage.

	Population	Study design	Previous vaginal delivery	Previous CS	Relative risk preterm birth	Confidence interval	P-value
Kietpeerakool et al. (2019)	173 124 multiparous women with consecutive pregnancies across 359 health facilities in 29 countries in Africa, Asia, Latin America and the Middle East 2010–2011	Secondary analysis of data collected from the WHO Multi-country Survey on Maternity and Child Health	6.7 %; 9344/139857 ('without previous CS' – all vaginal deliveries)	8.4 %; 2816/33267 (all CS)	1.26	1.21–1.31	< 0.0001
Visser et al. (2020)	268 495 women with two consecutive singleton pregnancies in the Netherlands 1999–2009	Retrospective cohort study using Perined Database	0.7 %; 1677/226167 (all vaginal deliveries)	1.1 %; 479/42328 (all CS)	1.53	1.38–1.69	< 0.0001
Williams et al. (2021)	16 340 women with first two consecutive singleton births from two maternity units in Scotland, UK 2009–2018	Retrospective cohort study	2.0 %; 241/12223 (operative and spontaneous vaginal deliveries)	5.2 %; 77/1492 (first stage CS and FDCS)	2.61	2.03–3.36	< 0.0001
Van Winsen et al. (2021)	30 840 women with two consecutive deliveries in 15 maternity units in North-West London 1988–2000	Retrospective cohort study	3.0 %; 707/23277 (operative and spontaneous vaginal delivery)	6.3 %; 76/1195 (first stage CS and FDCS)	2.09	1.66–2.63	< 0.0001
Gugusheff et al. (2021)	242 438 women with two consecutive deliveries in New South Wales, Australia 2005–2017	Retrospective cohort study using NSW Perinatal Data Collection	3.4 %; 5875/173160 (operative and spontaneous vaginal delivery)	4.4 %; 3046/69398 (all CS)	1.29	1.24–1.35	< 0.0001
Offringa et al. (2022)	7776 women with two consecutive births at Toulouse University Hospital, France 2003–2018	Retrospective cohort study	2.8 %; 221/7776 (vaginal delivery)	3.8 %; 54/1406 (all CS)	1.35	1.01–1.81	0.04
Suff et al. (2022)	259 women with two-three consecutive pregnancies in a tertiary London unit, UK 1995–2019	Retrospective cohort study	20 %; 40/200 (vaginal delivery)	54 %; 32/59 (first stage CS and FDCS)	2.71	1.87–3.90	< 0.0001
Zhou et al. (2022)	18253 women who had two consecutive deliveries in three Chinese Teaching Hospitals, China 2012–2022	Retrospective cohort study	5.5 %; 583/10591 (vaginal delivery)	9.6 %; 704/7302 (first stage CS and FDCS)	1.75	1.58–1.95	< 0.0001

Table 2: Summary of studies assessing risk of preterm birth < 37 following caesarean section; CS – caesarean section; FDCS – full dilatation caesarean section

3.1. Mechanism of increased sPTB risk associated with in-labour caesarean

The exact mechanism underlying the increased risk of sPTB following a CS remains to be elucidated, however cervical caesarean damage, is a possible explanation [14].

Surgical damage sustained at the level of the internal os would disrupt the integrity, and result in compromised cervical function in future pregnancies. This is more likely at the time of in-labour or full dilatation CS, as during labour the cervical tissue effaces and becomes continuous with the lower segment, and the cervix is drawn up over the presenting part where the CS incision is made (Fig. 1). Long labours associated with oedamatous and stretched tissues may increase in the risk of surgical trauma including extensions. Moreover, as labour progresses the fetal head is lower in the maternal pelvis, and can be more difficult to deliver, compounding this issue further[15].

This is supported by a recent study by Eriksson et al. which demonstrated that a fetal head at low station at the time of first CS increases the risk of sPTB < 32 weeks in subsequent pregnancy, OR 1.73 (CI 1.05–1.82)[36] This is in keeping with findings by Helman et al. which illustrated that women with a previous CS for failed instrumental delivery, a powerful surrogate for a low fetal head, were more likely to have a sPTB compared to those who had a full dilatation CS for another reason 8.2 % versus 3.8 % [37]. The extent of cervical caesarean damage may also be influenced by the presence of surgical site extensions [5, 14] and other factors such as suture material at the time of caesarean section, the healing process and incidence of post-operative infection. Further work needs to be done to explore these.

Following CS, a scar can be visualised by transvaginal ultrasound as a hypoechogenic discontinuity of the myometrium in the anterior uterine wall [38]. It is classified as a niche if the indentation is > 2 mm[38] (Fig. 2). In a Swedish cohort the frequency of large scar defects or niches increased when the incision was low, at the site of the internal os rather than above it in the lower segment, suggesting that site of incision may be related to subsequent pathology [39]. Another study demonstrated a statistically significant correlation between cervical dilatation at the time of the CS and the position of the CS scar [44]. The scar was positioned in the uterus above the cervical internal os in 97.1 % of women delivered at a cervical dilatation of 0–2 cm and located at or below the cervical internal os in 97.7 % of cases delivered at a cervical dilatation of 8–10 cm ($p < 0.001$) [40]. Studies have shown that assessing the CS scar and niche is reproducible both in non-pregnant and pregnant women. This includes the assessment of the location of the scar in relation to the internal os [38,41–43]. A recent study illustrated that a CS scar located < 5.0 mm above or below the internal os was associated with cervical shortening and sPTB [44]. The CRAFT study, due to report, also evaluates ultrasound and MRI as imaging modalities for assessing the risk and management of women with a history of full dilatation CS [35].

At present the surveillance and management of women at risk of sPTB is based on cervical length cervical length scanning [45]. In the future the use of CS scar and niche measurements on US, and possibly MRI, may be useful clinically in managing future pregnancies of women with previous CS [35].

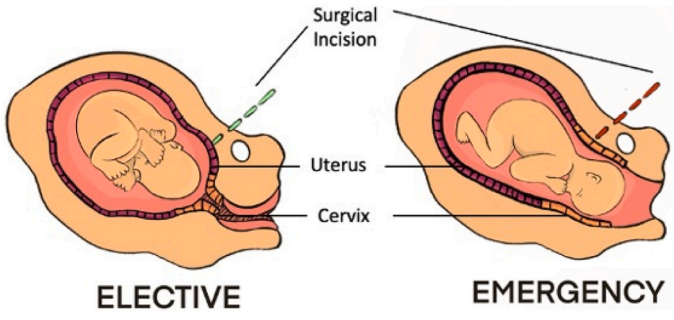

Fig. 1. Figure Illustrating Proposed Site of Surgical Incision at time of Elective versus Emergency/In-Labour CS.

3.2. Screening and management of women with previous in-labour CS

All women at high risk of sPTB should be screened in pregnancy, and as per *Saving Babies' Lives Version Three* full dilatation CS is now recognised as an intermediate risk factor for sPTB. The current recommendation is to perform a single transvaginal cervical length between 18 and 22 weeks of gestation [46,47]. In-labour CS is not recognised as an independent risk factor, however cervical caesarean damage may occur at any dilatation [4]. Therefore identifying, and predicting which women are at most risk is a priority, an area where imaging of the CS scar imaging may prove clinically relevant in the future [44].

Treatment modalities to reduce sPTB include vaginal progesterone, Arabin pessary and cervical cerclage insertion [45,46]. Studies investigating the efficacy of these treatments have not been sufficiently powered to analyse which benefit each underlying risk factor for sPTB. Therefore, at present there remains a paucity of evidence for which intervention would be most beneficial for women at risk of sPTB following a CS. Therefore, guidance suggests that interventions should be individualised based on history and clinical assessment [46].

Currently Arabin pessary is not routinely recommended in this cohort of women, and progesterone therapy may be considered [48,49]. Transvaginal cerclage has been shown to be considerably less effective in women with a prior emergency CS compared with other patients at high risk with a cerclage[13,50]. A retrospective case-control study demonstrated that women with a previous emergency CS followed by a sPTB at 24–36 + 6 weeks were more likely to deliver at < 30 weeks of gestation in their subsequent pregnancy despite a transvaginal cerclage, RR 9.4 (95 % CI 3.6–24.2, $P < .001$) [13]. Furthermore, a retrospective cohort study demonstrated that transabdominal cerclage was associated with less sPTB at < 30 weeks compared to transvaginal cerclage in women with a history of full dilatation CS and subsequent sPTB or mid-trimester loss, OR 0.09 (95 % CI 0.00–0.59; P = 0.008)[50]. Transabdominal cerclage has been suggested as the appropriate intervention to solve this problem as it enables the surgeon to place a cerclage above the cervical caesarean scar defect [51].

However, again, the current evidence is based on retrospective analysis of small cohorts. Therefore, further prospective evidence is required to elucidate the optimum treatments in this cohort. The ABOVE trial is a newly funded randomised control trial which will investigate transvaginal versus transabdominal cerclage in women with previous in-labour CS followed by a mid-trimester loss or sPTB [ISCRTN 109779960].

4. Conclusion

The emerging evidence demonstrating the association between CS and risk of subsequent sPTB and mid-trimester loss, compounded by escalating rates of CS globally, has revealed this as a substantive clinical issue which needs evaluation. This is confounded by the fact that in this group of women the preterm births tend to be early, recurrent, and difficult to treat by current interventions. There is a paucity of evidence regarding optimal management strategies in this cohort of women. Therefore, further research needs to establish the appropriate screening, surveillance, and treatment strategies. Moreover, prevention is better than cure. Curbing the overuse of in-labour CS and therefore limiting the incidence of cervical caesarean damage, should be a priority through training in the management of labour and instrumental deliveries. Overall, the implications of CS, especially in-labour and at full dilatation, need to be recognised and considered in shared decision making when deciding on mode of delivery and risk-stratification of future pregnancies.

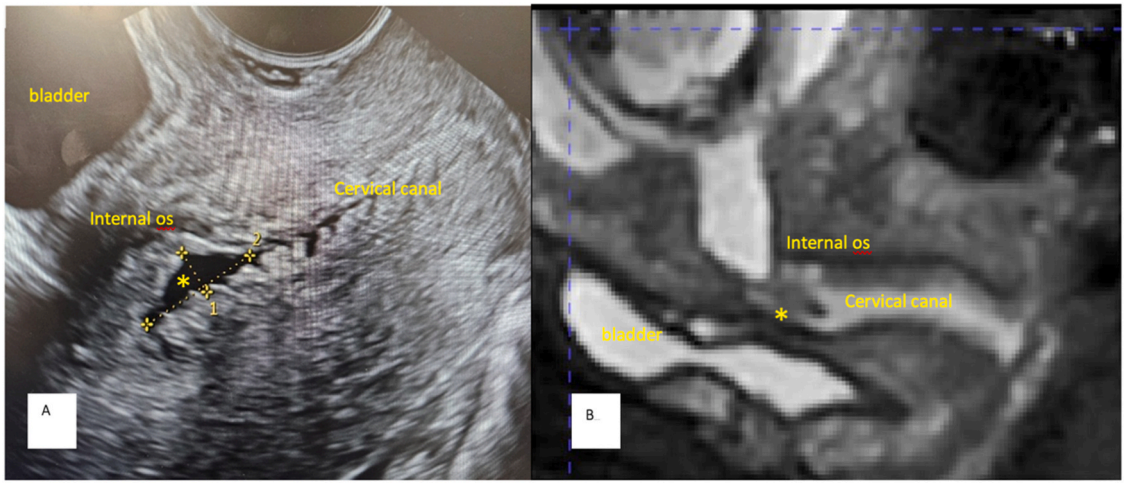

Fig. 2. TVUS (A) and T2 3D MRI reconstruction (B) demonstrating a cervical niche (*) at 23 weeks in a pregnancy following a full dilatation section [CRAFT-IMG study REC 19/L0/1270].

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CRediT authorship contribution statement

Suff Natalie: Writing – review & editing. **Shennan Andrew:** Writing – review & editing, Supervision. **van der Krogt Laura:** Writing – original draft. **Glazewska-Hallin Angnieszka:** Writing – review & editing. **Story Lisa:** Writing – review & editing, Supervision, Conceptualization.

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.

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