Original Article

Decision-to-delivery interval and neonatal outcomes for category-1 caesarean sections during the COVID-19 pandemic

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Summary

General anaesthesia is known to achieve the shortest decision-to-delivery interval for category-1 caesarean section. We investigated whether the COVID-19 pandemic affected the decision-to delivery interval and influenced neonatal outcomes in patients who underwent category-1 caesarean section. Records of 562 patients who underwent emergency caesarean section between 1 April 2019 and 1 July 2019 in seven UK hospitals (pre-COVID-19 group) were compared with 577 emergency caesarean sections performed during the same period during the COVID-19 pandemic (1 April 2020–1 July 2020) (post-COVID-19 group). Primary outcome measures were: decision-to-delivery interval; number of caesarean sections achieving decision-to-delivery interval < 30 min; and a composite of adverse neonatal outcomes (Apgar 5-min score < 7, umbilical arterial pH < 7.10, neonatal intensive care unit admission and stillbirth). The use of general anaesthesia decreased significantly between the pre- and post-COVID-19 groups (risk ratio 0.48 (95%CI 0.37–0.62); p < 0.0001). Compared with the pre-COVID-19 group, the post-COVID-19 group had an increase in median (IQR [range]) decision-to-delivery interval (26 (18–32 [4–124]) min vs. 27 (20–33 [3–102]) min; p = 0.043) and a decrease in the number of caesarean sections meeting the decision-to-delivery interval target of < 30 min (374/562 (66.5%) vs. 349/577 (60.5%); p = 0.02). The incidence of adverse neonatal outcomes was similar in the pre- and post-COVID-19 groups (140/568 (24.6%) vs. 140/583 (24.0%), respectively; p = 0.85). The small increase in decision-to-delivery interval observed during the COVID-19 pandemic did not adversely affect neonatal outcomes.

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Introduction

The National Institute for Health and Care Excellence (NICE) and the Royal College of Obstetricians and Gynaecologists specify that the urgency of a caesarean section should be categorised and documented using a four-point scale [1-3]. According to this, a category-1 caesarean section is classed as an emergency with an "*immediate threat to the life of the woman or the fetus*". Guidelines from NICE recommend that category-1 caesarean section should be performed as soon as possible after making the decision, but a decision-to-delivery interval within 30 min is used as a guide to measure the performance of obstetric units in the UK. The National Maternal and Perinatal Audit reported that over 167,500 caesarean sections were carried out in England, Wales and Scotland in 2016–2017, with almost 15% of these classified as emergency or category-1 [4]. Previous reviews have shown that category-1 caesarean sections are associated with poor neonatal outcomes, specifically relating to neonatal intensive care unit (NICU) admissions and neonatal respiratory and neurological morbidity [5].

The World Health Organization declared COVID-19 to have reached pandemic status on 11 March 2020 [6]. Our previous work showed that during the first wave of the COVID-19 pandemic (1 April 2020–1 July 2020), the general anaesthesia rate for caesarean sections in the north-west of England decreased significantly from 7.7% to 3.7% [7]. Several studies have shown that general anaesthesia is typically associated with achieving the shortest decision-to-delivery interval for category-1 caesarean section [8, 9]. The increased use of regional anaesthesia during the pandemic might, therefore, have impacted on the decision-to-delivery interval for category-1 caesarean sections and adversely influenced neonatal outcomes [10].

Though multiple reviews on maternal and neonatal outcomes during the COVID-19 pandemic have been published [11–13], we failed to find any study reporting on the decision-to-delivery interval for category-1 caesarean section during this period. Therefore, we conducted a retrospective observational review of category-1 caesarean sections performed in seven hospitals across the north-west of England during the first wave of COVID-19 pandemic with a matched period in the previous year, to assess the impact of the increased use of regional anaesthesia on decision-to-delivery interval and neonatal outcomes.

Methods

We reviewed the electronic and paper records of all women who delivered by category-1 caesarean section at seven hospitals across the north-west of England between 1 April 2019 and 1 July 2019 (pre-COVID-19 group). This was compared with data obtained from the same hospitals during the corresponding period in 2020 which represented the peak of the first wave of the COVID-19 pandemic (post-COVID-19 group). Hospitals with > 5000 annual deliveries (St Mary's Hospital, Manchester; Liverpool Women's Hospital, Liverpool; East Lancashire Hospitals NHS Trust, Burnley; and Royal Bolton Hospital, Bolton) and < 5000 annual deliveries (Wrightington Wigan and Leigh Hospital, Wigan; Royal Preston Hospital, Preston; and Wythenshawe Hospital, Manchester) participated in data collection. Research ethics committee approval was not required for this project as the data we analysed are collected routinely for audit purposes (e.g. against standards specified by NICE [1], the Royal College of Anaesthetists (RCoA) [14] and the National Maternal and Perinatal Audit [4]). Appropriate governance approvals for data collection and sharing were followed at all participating institutions.

Specific maternal information collected in the audit included: age; BMI; parity; maternal medical history; suspected sepsis before delivery; gestational age at delivery; indication for category-1 caesarean section; anaesthetic technique used for the caesarean section; vasopressors used during the caesarean section; anaesthetic and surgical personnel performing the caesarean section; decision-to-delivery interval; decision-to-theatre interval; theatre-to-incision interval; and theatre-to-delivery interval. Neonatal data collected included: birth weight; Apgar scores at 1, 5 and 10 min; arterial and venous umbilical cord pH; neonatal tracheal intubation rate; neonatal NICU admission; and neonatal stillbirth. Additional information specific to the pandemic comprised the SARS-CoV-2 infection status of the women and the neonate(s) after birth.

Primary outcomes analysed in this study included: decision-to-delivery interval; number of caesarean sections achieving decision-to-delivery interval target < 30 min; and a composite of adverse neonatal outcomes (Apgar score < 7 at 5 min, umbilical arterial pH < 7.10, requirement for NICU admission and stillbirths). Secondary outcomes included: decision-to-theatre interval; theatre-to-incision interval; theatre-to-delivery interval; Apgar scores at 1 and 5 min; umbilical artery and umbilical vein pH; and neonatal tracheal intubation rates.

Statistical analyses were stratified by mode of anaesthesia and hospital to obtain pooled estimates with 95%CI. Continuous data were analysed using Mann-Whitney U-statistics, Kruskal-Wallis H-statistics and general

linear models with Tukey multiple comparison corrections to p-values and 95%CIs as appropriate. The Mantel-Haenszel chi-square statistic was used to estimate the pooled risk ratio (RR) (95%CI) stratified by hospital. Robust logistic or conditional logistic regression was used to estimate adjusted odds ratio (OR) with 95%CI between or stratified by hospitals. Fisher's expanded exact p-values were used to compare distributions in categories. Based on the mean (SD) pre-COVID-19 decision-to-delivery interval of 26 (15) min at St Mary's Hospital, at least 551 parturients were required in each period to find a 3-min difference in this interval (assuming $p < 0.05$ and 90% power). This sample size would also have 80% power to find a RR ≥1.3 (baseline proportion of 0.26 at St Mary's Hospital) for the composite of adverse neonatal outcomes. Analyses were performed using Number Cruncher Statistical Systems 2020, (NCSS Inc., Kaysville, UT, USA) and Stata 16.1 (StataCorp Inc., College Station, TX, USA). Statistical significance was defined at $p < 0.05$ (two-sided).

Results

The rates for category-1 caesarean sections across the seven hospitals were similar in the pre- and post-COVID-19 study periods (562/2866 (19.6%) and 577/2928 (19.7%), respectively; $p = 0.93$). Maternal characteristics, comorbidities, gestational age at time of delivery and the indications for caesarean section were comparable in both periods (Table 1). A significant increase in the presence of a consultant obstetrician operating in theatre was noted in the electronic records in the post-COVID-19 period compared with the pre-COVID period (21.8% vs. 14.1%, RR 1.55 (95% CI 1.20–2.01); $p = 0.0005$). This was predominantly the case for category-1 caesarean sections performed between 08:00 and 20:00. The use of general anaesthesia for category-1 caesarean section decreased significantly between the pre- and post-COVID-19 periods (RR 0.48 (95% CI 0.37–0.62); $p < 0.0001$). The regional to general anaesthesia conversion rate across the seven hospitals also saw a significant decline (RR 0.41 (95%CI 0.21–0.81); $p = 0.0099$) (Fig. 1).

Our primary outcome measure of decision-to-delivery interval increased between the pre- and post-COVID-19 groups (median (IQR [range]) 26 (18–32 [4–124]) min vs. 27 (20–33 [3–102]) min; $p = 0.043$) (Table 2). Comparing anaesthetic techniques across both time periods, spinal anaesthesia was associated with the longest decision-to-delivery interval for category-1 caesarean sections (Table 2). The overall number of category-1 caesarean sections meeting the decision-to-delivery interval target of < 30 min was significantly higher in the pre- compared with the post-COVID-19 group (66.5% vs. 60.5% respectively, RR 0.90 (95%CI 0.74–0.99); $p = 0.02$) (Table 2). When stratified by anaesthetic technique, this difference was significant for caesarean section using general anaesthesia, but not spinal anaesthesia or an epidural top-up (Table 2).

No difference was noted in the overall composite of adverse neonatal outcomes between the pre- and post-COVID-19 periods (24.7% vs. 24.0%, RR 0.98 (95%CI 0.80–1.20); $p = 0.85$) (Table 3). Overall, the COVID-19 pandemic, decision-to-delivery interval and achievement of a target decision-to-delivery interval of < 30 min did not affect composite neonatal outcomes (Table 4). Gestational age of the neonate at the time of birth and prematurity (defined as < 37 weeks' gestation) were, however, significant predictors of adverse neonatal outcome (Table 4). Pooled data from both study periods highlights that use of general anaesthesia for category-1 caesarean section was associated with worse composite neonatal outcomes (Tables 3 and 4).

Secondary outcomes show a statistically significant increase in the decision-to-theatre interval and theatre-to-incision interval during the COVID-19 pandemic (Table 5). However, no significant differences were observed in any other secondary outcome measures between the study periods (Table 5).

The SARS-CoV-2 infection status (as diagnosed by positive reverse transcriptase polymerase chain reaction (PCR) on nasopharyngeal swab) was unknown in 185 women (32.1%). Of those with SARS-CoV-2 PCR results, five women (< 1%) were confirmed to have SARS-CoV-2 infection; all these patients were during the post-COVID-19 period and all received a spinal anaesthetic for their category-1 caesarean section. The decision-to-delivery interval in these patients ranged from 19 to 40 min and four women had an interval > 30 min. None of the neonates had a positive SARS-CoV-2 swab.

Discussion

To our knowledge, this is the first study to examine the impact of the COVID-19 pandemic on the decision-to-delivery interval for category-1 caesarean section. We observed a small increase in median decision-to-delivery interval during the post-COVID-19 study period. This, along with increases in decision-to-theatre and theatre-to-incision intervals during the pandemic, might be explained by the recommendations of multiple societies to don airborne personnel protective equipment (PPE) before the arrival of a patient into the operating theatre [15, 16]. The aim of this guidance was to decrease the risk of SARS-CoV-2 transmission to healthcare workers during caesarean sections performed

Table 1 Parturient and obstetric characteristics for category-1 caesarean sections before (pre-COVID-19) and after (post-COVID-19) the onset of the COVID-19 pandemic. Values are median (IQR [range]) or number (proportion). Day is defined as 08:00–20:00 and night as 20:00–08:00

	Pre-COVID-19 n = 562	**Post-COVID-19 n = 577**	**p value**
Age; years	31 (27–35 [15–47])	31 (27–34 [17–46])	0.12
BMI; $kg.m^2$	26 (23–30 [17–54])	26 (23–31 [15–47])	0.18
Gestation; weeks	39 (38–40 [24–43])	39 (37–40 [24–43])	0.46
Premature	78 (13.9%)	89 (15.4%)	0.46
Parity	0 (0–1 [0–7])	0 (0–1 [0–8])	0.15
Primiparous	337 (60.0%)	367 (63.6%)	0.20
Previous caesarean section	63 (11.2%)	70 (12.1%)	0.58
Comorbidities			0.26
Obesity	135 (24.0%)	164 (28.4%)	
Sepsis	49 (8.7%)	41 (7.1%)	
Hypertension/Pre-eclampsia	39 (6.9%)	44 (7.6%)	
Diabetes	38 (6.8%)	45 (7.8%)	
Asthma	31 (5.5%)	37 (6.4%)	
Haematological	14 (2.5%)	11 (1.9%)	
Cardiac	9 (1.6%)	8 (1.4%)	
Hypothyroidism	2 (0.4%)	4 (0.7%)	
Cholestasis	1 (0.2%)	1 (0.2%)	
Systemic lupus	1 (0.2%)	2 (0.3%)	
Chronic renal disease	-	1 (0.2%)	
SARS-CoV-2 infection	-	5 (0.9%)	
Indication(s) for caesarean section			0.55
Abnormal cardiotocography	344 (61.2%)	356 (61.7%)	
Dystocia	62 (11.0%)	48 (8.3%)	
Failed instrumental delivery	39 (6.9%)	50 (8.7%)	
Antepartum haemorrhage/placenta praevia	29 (5.2%)	43 (7.5%)	
Fetal acidosis	35 (6.2%)	32 (5.5%)	
Malpresentation	27 (4.8%)	24 (4.2%)	
Umbilical cord prolapse	11 (2.0%)	12 (2.1%)	
Pre-eclampsia	4 (0.7%)	2 (0.3%)	
Uterine scar	2 (0.4%)	3 (0.5%)	
Sepsis	2 (0.4%)	-	
Operation at night	289 (51.4%)	321 (55.6%)	0.17
Anaesthetic consultant present	141 (25.1%)	128 (22.2%)	0.24
Day	106/273 (38.8%)	90/256 (35.2%)	0.42
Night	35/289 (12.1%)	38/321 (11.8%)	0.99
Obstetric consultant present	79 (14.1%)	126 (21.8)	0.0005
Day	37/273 (13.6%)	67/256 (26.2%)	0.0003
Night	42/289 (14.5%)	59/321 (18.0%)	0.23
Vasopressor used			0.021
Phenylephrine	323 (57.5%)	361 (62.6%)	
Ephedrine	15 (2.7%)	4 (0.7%)	
Other	38 (6.8%)	44 (7.6%)	

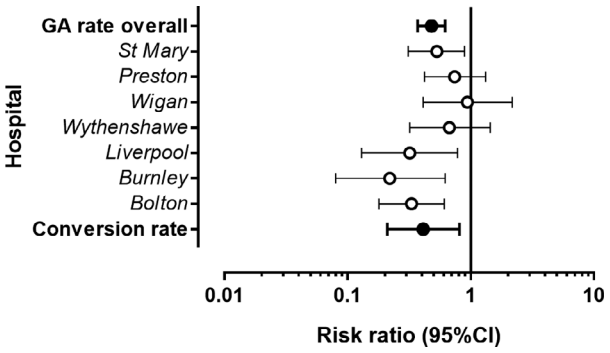

Figure 1 General anaesthesia (GA) rates are presented as risk ratio and 95% confidence interval (CI). Data were analysed using Mantel-Haenszel chi-square statistics, stratified by hospital

under a general anaesthesia (or regional anaesthesia deemed at high-risk of conversion to general anaesthesia) since tracheal intubation is an aerosol-generating procedure. The use of PPE will have increased the operating theatre staff preparation time for emergency caesarean section. The recommendations also suggested that patients with suspected or confirmed SARS-CoV-2 infection should be 'last in' to the operating theatre, potentially contributing to an increase in the decision-to-theatre interval.

Routine PCR testing for SARS-CoV-2 was not available across maternity units in the UK until relatively late in the first wave of the pandemic and was typically restricted to patients with COVID-19 symptoms. Since almost 14% of nasopharyngeal swabs among asymptomatic parturients were reported to be positive for SARS-CoV-2 [17], we postulate that healthcare workers may have taken a cautious approach and used airborne PPE for all category-1 caesarean sections, including those in asymptomatic patients whose SARS-CoV-2 status was unknown. In addition, given the unavoidable continuation of obstetric work throughout the early phase of the pandemic, more

Table 2 Anaesthetic techniques and decision-to-delivery intervals for category-1 caesarean sections before (pre-COVID-19) and after (post-COVID-19) the onset of the COVID-19 pandemic. Values are median (IQR [range]) or number (proportion)

	Pre-COVID-19 n = 562	Post-COVID-19 n = 577	Difference or ratio (95%CI)	p value
Decision-to-delivery interval; min	26 (18–32 [4–124])	27 (20–33 [3–102])	1.0 (0.0–3.0)	0.043
Anaesthesia				<0.0001
General	19 (14–25 [7–86])	21 (18–30 [4–66])	2.9 (−2.1–7.9)	0.56
Spinal	28 (24–36 [4–124])	29 (24–36 [4–102])	2.5 (−0.6–5.5)	0.19
Epidural top-up	24 (17–31 [4–67])	23 (17–29 [3–54])	-2.4 (−7.2–2.5)	0.72
Decision-to-delivery interval < 30 min	374/562 (66.5%)	349/577 (60.5%)	0.90 (0.83–0.98)	0.020
Anaesthesia				<0.0001
General	123/142 (86.6%)	55/74 (74.3%)	0.86 (0.74–0.99)	0.037
Spinal	175/311 (56.3%)	190/366 (51.9%)	0.92 (0.80–1.06)	0.28
Epidural top-up	76/109 (69.7%)	104/137 (75.9%)	1.09 (0.93–1.27)	0.31

Table 3 Composite measure of adverse neonatal outcomes for category-1 caesarean sections before (pre-COVID-19) and after (post-COVID-19) the onset of the COVID-19 pandemic. Values are number (percentage)

	Pre-COVID-19 n = 568	Post-COVID-19 n = 584	Ratio (95%CI)	p value
Overall composite measure	140/568 (24.6%)	140/584 (24.0%)	0.98 (0.80–1.20)	0.85
Anaesthesia				<0.0001
General	61/143 (42.7%)	28/76 (36.8%)	0.86 (0.60–1.21)	0.47
Spinal	67/314 (21.3%)	98/371 (26.4%)	1.24 (0.95–1.63)	0.13
Epidural top-up	12/111 (10.8%)	14/137 (10.2%)	0.95 (0.46–1.94)	0.99
Composite Items				
Apgar score < 7 at 5 min	25/530 (4.7%)	32/566 (5.7%)	1.20 (0.72–1.99)	0.50
Umbilical artery pH < 7.10	50/463 (10.8%)	53/502 (10.6%)	0.98 (0.68–1.41)	0.92
NICU admission	100/568 (17.6%)	100/584 (17.1%)	0.97 (0.76–1.54)	0.88
Stillbirth	4/568 (0.7%)	4/584 (0.7%)	0.96 (0.26–3.47)	0.99

NICU, neonatal intensive care unit.

Table 4 Factors influencing adverse neonatal outcome in category-1 caesarean section

	Odds ratio (95%CI)	p value
Period pre-/post-COVID-19	0.97 (0.72–1.32)	0.87
General anaesthesia	2.67 (1.39–5.15)	0.003
Decision-to-delivery interval; min	1.003 (0.99–1.02)	0.65
Decision-to-delivery interval < 30 min	0.95 (0.69–1.32)	0.77
Gestational age	0.75 (0.67–0.83)	<0.0001
Prematurity (< 37 weeks)	8.32 (5.03–13.76)	<0.0001

limited time was available for multidisciplinary simulation training in the use of PPE when compared with other surgical specialities [18]. These factors may both have contributed to the significant decline in the number of caesarean sections performed using general anaesthesia meeting the decision-to-delivery interval target of < 30 min in the post-COVID-19 study period. The incision-to-delivery interval was not increased, and we suggest this may be due to the increased presence of consultant obstetricians, who were resident on a 24-h basis during the pandemic study period in four of the seven hospitals in our study.

Failure to meet the decision-to-delivery interval < 30 min target was observed in 33.5% of all caesarean sections before the pandemic, consistent with the findings of Bloom et al. [19]. This increased significantly to 39.5% in the post-COVID-19 study period but without any associated increase in poor neonatal outcomes. This reinforces the concept that a decision-to-delivery interval target of 30 min is empirical and any increase may not necessarily influence neonatal outcomes. This is in line with the findings of multiple studies of emergency caesarean sections outside the context of COVID-19 [19–23].

General anaesthesia was associated with the shortest decision-to-delivery, decision-to-theatre and theatre-to-incision intervals in the pre-COVID-19 period. This finding is in line with existing literature [24, 25]. During the post-COVID-19 study period, median decision-to-delivery interval using general anaesthesia increased from 19 min to 21 min but was still shorter than when a spinal or epidural top-up technique was used, despite the recommendations to don PPE. This emphasises that for the most pressing emergencies, general anaesthesia may still be the most appropriate choice of technique. Spinal anaesthesia was associated with the longest decision-to-delivery interval of 28 min, in keeping with the literature [26, 27]; this increased to 29 min in the post-COVID-19 study period. The greater time for spinal anaesthesia compared with general anaesthesia is likely to reflect the time needed to prepare and perform the procedure, and the unpredictable time for surgical anaesthesia to be established. It nevertheless remained the most popular technique utilised in the pre- and post-pandemic periods, a decision which we postulate was driven by the typically excellent quality of block, lower rate of conversion to general anaesthesia (hence lower risk of an aerosol-generating procedure) and superior postoperative analgesia.

Epidural top-up anaesthesia was associated with a shorter decision-to-delivery interval compared with spinal anaesthesia by a margin of 4 min pre-COVID-19, and this difference increased to 6 min during the post-COVID-19 study period. This might be attributed to the guidance to offer epidural labour analgesia to SARS-CoV-2 positive or those suspected of having SARS-CoV-2 infection, as well as the advice to commence the topping-up of labour epidurals

Table 5 Effect of the COVID-19 pandemic on secondary outcome measures for category-1 caesarean sections before (pre-COVID-19) and after (post-COVID-19) the onset of the COVID-19 pandemic. Values are median (IQR [range]) or number (percentage)

	Pre-COVID-19 n = 568	Post-COVID-19 n = 584	Difference or ratio (95%CI)	p value
Decision-to-theatre; min	7 (3–10 [0–73])	8 (4–11 [0–76])	1.0 (0.0–1.0)	0.0097
Theatre-to-incision; min	17 (13–22 [0–69])	18 (15–24 [5–52])	2.0 (1.0–3.0)	0.0028
Theatre-to-delivery; min	20 (16–27 [2–93])	21 (16–26 [4–58])	1.0 (0.0–2.0)	0.23
Apgar score at 1 min	9 (7–9 [0–10])	9 (8–9 [0–10])	0.0 (0.0–0.0)	0.76
Apgar score at 5 min	10 (9–10 [0–10])	10 (9–10 [0–10])	0.0 (0.0–0.0)	0.099
Uterine artery pH	7.22 (7.16–7.27 [6.80–7.51])	7.22 (7.16–7.28 [6.75–7.42])	0.0 (0.0–0.0)	0.57
Uterine vein pH	7.28 (7.22–7.32 [6.80–7.43])	7.28 (7.21–7.33 [6.80–7.42]	0.0 (0.0–0.0)	0.69
Birth weight; g	3267 (2765–3657 [670–5920])	3235 (2852–3630 [640–5186])	0.0 (0.0–76.0)	0.96
Neonatal intubation	28 (4.9%)	30 (5.1%)	1.0 (0.6–1.7)	0.89

before transfer to the operating theatre during the pandemic [15]. This may also explain the finding that the epidural top-up rate for caesarean section increased in the post-COVID-19 study period from 70% to 75%. During the COVID-19 pandemic, median decision-to-delivery interval for general anaesthesia was shorter by 2 min compared with epidural top-up anaesthesia. This difference is similar to that demonstrated by Warren et al. in their study on immediate time-critical births, though overall decision-to-delivery interval was much shorter [24]. In their analysis comparing epidural and general anaesthesia for category-1 caesarean section, Bidon et al. found that protocolised epidural top-ups, commenced in delivery rooms, can achieve a decision-to-delivery interval which is shorter than that using a general anaesthetic, without compromising neonatal outcomes [28].

We did not find any evidence of an increase in adverse neonatal outcomes associated with the reduction in general anaesthesia rates during the post-COVID-19 study period. Our findings of adverse short-term composite neonatal outcomes with general anaesthesia for category-1 caesarean section are in line with the published studies on category-1 caesarean section [28–30]. The association of general anaesthesia with adverse neonatal outcomes is not causative but is due to confounding by indications. Figure 2 shows the significant dependency of general anaesthesia rate on indications for category-1 caesarean section ordered by adverse neonatal outcomes. Chi-square trend analysis shows a significant 5.6% (95%CI 4.2–7.00; $p < 0.0001$) change in general anaesthesia rate per indication category ordered by neonatal morbidity. Rates of general anaesthesia were significantly greater for pre-eclampsia, antepartum haemorrhage/placenta praevia, cord prolapse and malpresentations, all of which are associated with adverse neonatal outcomes. These compromised fetuses (the confounding variable) require swift delivery, which is most reliably achieved with general anaesthesia. However, they may also be more vulnerable to the depressant effects of general anaesthetic agents leading to lower Apgar scores and higher rates of umbilical arterial pH < 7.10, requirement for tracheal intubation and NICU admission. There was a significant increase in the use of phenylephrine during the post-COVID-19 period which may have contributed to the lower rates of umbilical arterial pH < 7.10 for neonates in the regional anaesthesia group. This has been highlighted by Singh et al. in their Bayesian network meta-analysis on vasopressor drugs for caesarean section [31].

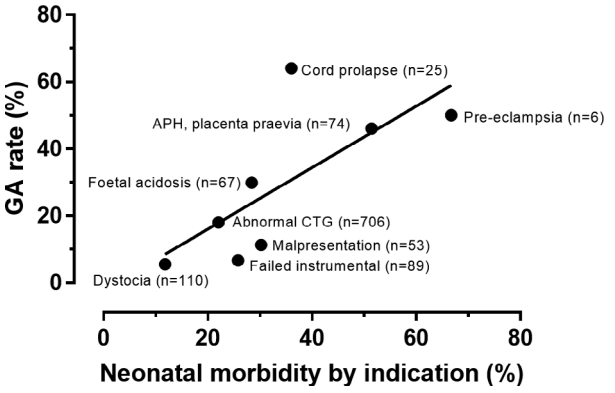

Figure 2 The significant dependency of general anaesthesia (GA) on indication ordered by neonatal morbidity is shown using non-parametric regression (median slope: 1.03% (95%CI 0.09–1.86), Spearman's rho correlation 0.81, $p = 0.022$). Chi-square trend analysis shows a significant 5.6% (95%CI 4.2–7.0); $p < 0.0001$) change in general anaesthesia rate per ordered indication category. There is a significant use of general anaesthesia for the top four indications combined with adverse neonatal outcomes (odds ratio 3.5 (95%CI 2.2–5.4); $p < 0.0001$). APH, antepartum haemorrhage; CTG, cardiotocography

In the five women with confirmed positive SARS-CoV-2 nasopharyngeal swabs, none of the neonates tested positive for SARS-CoV-2 and all had good neonatal outcomes despite decision-to-delivery intervals which were not consistently within the recommended target. Our dataset is too small to draw any meaningful conclusions regarding this finding.

The increased use of regional anaesthesia for category-1 caesarean section during the pandemic was not associated with an increase in adverse neonatal outcomes. The reasons for increased utilisation of regional techniques during the pandemic have been highlighted previously [7]. Our study confirms these findings and is likely to be reassuring for anaesthetists, obstetricians, the parturient and those societies recommending the preferential use of regional anaesthesia for emergency caesarean section during the COVID-19 pandemic. We would, however, caution anaesthetists not to be fixated on performing a regional anaesthetic as delays in delivery can lead to worse outcomes, as highlighted in the '*Each Baby Counts*' report [32]. It is essential that the anaesthetist, obstetrician and members of the multidisciplinary team attending a category-1 caesarean section communicate effectively with each other and are aware of the "*shared understanding of the urgency of delivery*", in line with the recommendations of the report. Anaesthetists need to make a risk-benefit analysis of the best choice of anaesthetic for individuals and continue working to improve the safety of delivery whichever anaesthetic technique is used.

The limitations of our study are that it is observational, retrospective, conducted over a limited period of time and subject to selection and information bias. It includes a limited number of hospitals in the north-west of England thus limiting the generalisability of our findings. We did not analyse specific anaesthetic or surgical factors contributing to an increase in decision-to-delivery interval, nor were the details of PPE worn during each caesarean section examined. Maternal outcomes and details of neonatal respiratory and neurological morbidity, along with 28-day neonatal mortality, were not reviewed.

We conclude that the there was a small, clinically unimportant increase in decision-to-delivery interval for category-1 caesarean section during the first wave of the COVID-19 pandemic. The increased use of regional anaesthetic techniques during the COVID-19 pandemic did not appear to adversely affect neonatal outcomes. Our analysis supports the safe use of regional anaesthesia for category-1 caesarean section except in those cases which warrant the most urgent delivery.

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