BACKGROUND: Occiput posterior is the most common malposition in labor. Deliveries in occiput posterior position have been shown to have higher rates of adverse short-term maternal and neonatal outcomes compared with deliveries in occiput anterior position. There are no guidelines providing recommendations nor summarizing risks of adverse outcomes by delivery method to inform the decision-making process in occiput posterior delivery management. Population-based studies examining the outcomes associated with various management processes of occiput posterior position at the time of labor or delivery are lacking.

OBJECTIVE: This study aimed to describe the current management of term singleton occiput posterior deliveries in British Columbia, Canada and to examine the association between different management strategies and adverse outcomes by describing the rates of: occiput posterior malposition; and spontaneous vaginal delivery, operative vaginal delivery, and cesarean delivery from occiput posterior malposition. We also analyzed the rates of adverse labor and delivery outcomes stratified by fetal position and delivery mode, and the interaction effect of occiput posterior position and delivery mode on the rates of adverse outcomes.

STUDY DESIGN: This was a retrospective cohort study of cephalic term singleton deliveries in British Columbia from 2004 to 2020, using the British Columbia Perinatal Data Registry. The obstetrical adverse outcome index (a composite of 10 adverse maternal or neonatal events), adverse outcome index subcomponent rates, and adverse outcome index—derived weighted scores were compared between deliveries stratified by fetal position at delivery (occiput posterior or occiput anterior) and occiput posterior deliveries stratified by delivery method. Multivariable log-binomial logistic regression was used to model the adverse outcome index score.

RESULTS: Of 306,237 term births, 19% had occiput posterior position during labor, 37% of which persisted in occiput posterior position at delivery. Among occiput posterior deliveries, 27% were spontaneous vaginal deliveries, 8% vacuum, 5% forceps, 1% mixed vacuum-forceps, and 59% were cesarean delivery; this distribution differed from that of occiput anterior deliveries ($P<.0001$). Overall, adverse outcome index scores were significantly higher in persistent occiput posterior deliveries (8.8% had $\geq1$ adverse outcomes; adjusted rate ratio, 1.07 [1.01–1.14]) than in occiput posterior labors that rotated to occiput anterior deliveries; the most frequent adverse outcome was third- or fourth-degree lacerations. Neonatal adverse outcomes were also more frequent in occiput posterior delivery (4.3% vs 3.3%; adjusted rate ratio, 1.21 [1.10–1.35]), whereas maternal outcomes were similar between groups (4.8% vs 6.0%; adjusted rate ratio, 1.04 [0.96–1.13]). Among persistent occiput posterior deliveries, spontaneous vaginal delivery and cesarean delivery had the lowest proportion of deliveries with $\geq1$ adverse outcomes (6.1% and 6.2%), whereas forceps deliveries had the highest (38.1%); the largest contributor to the adverse outcomes were third- or fourth-degree lacerations. Among occiput posterior deliveries with any adverse outcome, cesarean delivery had the highest Severity Index score, due in part to the inclusion of third- or fourth-degree tears (which are assigned a comparatively low score) as the most common adverse event in the other vaginal delivery modes, and because of outcomes with a higher severity score being associated with cesarean delivery, such as uterine rupture (a reason for cesarean delivery) and intensive care unit admission (an outcome following cesarean delivery). Overall, in a multivariable regression model, delivery mode and the interaction between delivery mode and occiput posterior position were significant predictors of a delivery with $\geq1$ adverse outcomes, whereas occiput posterior position itself was not.

CONCLUSION: One in five singleton deliveries at term gestation had occiput posterior position in labor; most of these rotated to occiput anterior by delivery, which had better outcomes than persistent occiput posterior deliveries. Among the latter, spontaneous vaginal delivery and cesarean delivery had the lowest frequency of adverse outcomes, whereas forceps deliveries had the highest. This study provides a robust updated analysis of birth outcomes following different occiput posterior management strategies, which can inform provider decision-making and
Introduction
Persistent occiput posterior (OP) position is the most common malposition in labor, with incidence between 1.8% and 8.4%.1–7 OP position is associated with prolonged labor, severe perineal tears, and postpartum hemorrhage.2–4,6,8–10 Moreover, 2 studies showed that only 30% of nulliparas and 55% of multiparas with fetuses in persistent OP position achieve spontaneous vaginal delivery (SVD).2,4 The same studies also reported cesarean delivery (CD) rates of 26% and 45% and operative vaginal delivery (OVD) rates of 45% and 29% for nulliparous women, with CD rates of 17% and 26% and OVD rates of 28% and 17% for multiparous women.2,3

Neonates delivered in OP position vs occiput anterior (OA) position have an increased risk of adverse short-term health outcomes, including increased rates of umbilical artery pH of <7 (1.8% vs 0.5%) and base excess of less than −12 (2.2% vs 0.9%).4,5 They also have higher rates of birth trauma, meconium aspiration, and neonatal intensive care unit (NICU) admission.4,5 Some studies found higher rates of 5-minute Apgar scores <7 among OP deliveries,5,6 whereas others found no differences relative to infants born in OA position.2,3

OP position is also associated with increased maternal complications. As a risk factor for obstetrical anal sphincter injury (OASI), its effects are comparable to those of nulliparity, prolonged second stage, episiotomy, shoulder dystocia, higher birthweight, and OVD.4,6,8,9 OASIs occur in 7% to 22% of OP deliveries vs 1% to 10% of OA deliveries.3,6,9 OVD—with forceps (odds ratio [OR], 8.4; confidence interval [CI], 8.0–8.7) or vacuum (OR, 3.9; CI, 3.8–4.1)—is an independent risk factor for OASI, but the combination of OP malposition and OVD poses even greater risk. A previous study showed a 33.1% risk of OASI during vacuum-assisted OP delivery vs 26.6% risk during vacuum-assisted OA delivery, and 71.6% risk in forceps-assisted OP vs 53.8% risk in forceps-assisted OA delivery.11 Later studies similarly showed that OP position increased the risk of OASI 3.1 times among forceps deliveries,12 and 4.0 times among vacuum deliveries.13,14 Rotation may decrease the risk of OASI; among forceps-assisted vaginal deliveries with documented OP malposition, delivery in a nonrotated OP position had increased rates of OASI (43.4%) compared with delivery in a rotated position (24.3%).15

Despite the associations of maternal and neonatal complications with OP malposition and subsequent modes of delivery, specific guidelines summarizing the risks of adverse outcomes by delivery management method to inform the decision-making process in OP delivery management are lacking. A large population study examined the risk factors and outcomes associated with persistent OP position,1 and a single-center study examined the risk factors and management processes for persistent OP position.16 However, to the best of our knowledge, no population study has examined the outcomes associated with different delivery methods for persistent OP position. The purpose of this study was to describe the current management of term singleton OP deliveries in British Columbia (BC), and to examine the association of different management strategies with adverse outcomes.

Materials and Methods

Study design
This was a retrospective cohort study of singleton term deliveries with documented position during labor and delivery. Stratification of the study population provided 3 groups: OA position in labor followed by OA delivery (OA/OA), OP malposition in labor that rotated to OA for delivery (OP/OA), and OP malposition that persisted at delivery (OP/OP). Information about OP malposition in labor was obtained from the BC Perinatal Data Registry (BCPDR), where it was documented without any further specification of stage, dilatation, or station. Because attempted manual rotations of position and some forceps rotations were not coded in our dataset, the OP/OA group included spontaneous rotations, manual rotations, and some forceps rotations (ie, those preceding ultimately CDs or SVDs; only forceps rotations followed by forceps or combined forces and vacuum deliveries were coded as such and thus could form a distinct group). The population was further stratified by delivery mode: SVD, vacuum, forceps, mixed vacuum-forceps, and CD.

We investigated the incidence of delivery modes by fetal position in labor and delivery. We compared the rates of adverse maternal and neonatal outcomes between: (1) the 3 position groups; and (2) the 5 delivery modes among women with OP deliveries. We assessed the interaction between the effects of OP position and delivery mode on the adverse outcome index (AOI) using multivariable log-binomial logistic regression.

The Research Ethics Board of The University of British Columbia provided ethics approval (#H21-00713). We report this study per the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cohort studies.

Study population
Our study population was drawn from all births in BC between April 1, 2004 and March 31, 2020. All data were obtained from the BCPDR; the time frame maximized our sample size following BCPDR parameter redefinitions in 2004. The
Why was this study conducted?
This study aimed to describe the management of occiput posterior (OP) deliveries in British Columbia (BC), Canada, and examine the association of management strategies with adverse outcomes.

Key findings
Overall, 19% of term singleton deliveries had OP position in labor, and 37% of these persisted in OP position at delivery (7% overall). In BC, persistent OP malposition was delivered in 59% of cases by cesarean delivery (CD), in 27% by spontaneous vaginal delivery (SVD), in 8% by vacuum (VD), in 5% by forceps (FD), and in 1% by mixed vacuum-forceps delivery (VFD). Inclusive of third- or fourth-degree lacerations, CD and SVD had the lowest proportion of deliveries with adverse outcomes (6.2% and 6.1%) compared with VD, FD, and VFD (14.6%, 38.1%, and 35.9%, respectively).

What does this add to what is known?
Our retrospective population-based cohort study described differences in adverse birth outcomes by mode of delivery in women with persistent OP position.

BCPDR is a validated population registry with records for >99% of births in the province (700,000 records since April 1, 2000) from 60 hospitals and most home births. The registry is maintained by Perinatal Services BC and abstracts 240 maternal and 94 newborn standard parameters documenting prenatal care, intrapartum care, and postpartum admissions using standardized medical record forms and abstraction.

Inclusion criteria were singleton, cephalic, and term pregnancies. Exclusion criteria were gestational age of <37+0 or ≥42+0 weeks, intrauterine fetal demise before labor, and known lethal congenital abnormalities. We excluded women with transverse or unknown positions in labor or at delivery and specific primary indications for CD including breech position, repeated CD, placental abruption, placenta previa, active herps, and maternal request. Thus, the study population included women who had a trial of vaginal delivery.

Outcome measures
The primary outcomes were: (1) incidence of OP malposition in labor and at delivery in singleton term births; (2) incidence of delivery mode for each fetal position group; (3) the AOI by fetal position and delivery mode; and (4) interaction effect of fetal position and delivery mode.

Secondary outcomes included: (1) subcomponent AOI rates, (2) the Weighted Adverse Outcome Score (WAOS), and (3) the Severity Index (SI), compared by fetal position groups and delivery modes.

The AOI is a composite of 10 adverse maternal or neonatal events related to labor and delivery. The WAOS assigns weights to each outcome on the basis of severity: maternal death (750), uterine rupture (100), maternal intensive care unit (ICU) admission (65), antiseptated operative procedure (40; eg, surgical control of bleeding, hysterectomy, repair of abdominal wall), blood transfusion (20), third- or fourth-degree perineal tear (5), intrapartum stillbirth or neonatal death (400), birth trauma (60), NICU admission (35), and 5-minute Apgar score <7 (25). We refer to an “AOI score” as the percentage of deliveries in which ≥1 of these adverse events occur. The WAOS is a per-delivery average weighted score, or the sum weight of all adverse events, divided by the total number of deliveries. The SI takes the sum weight and divides it by the total number of deliveries with an adverse event (instead of the total number of deliveries), giving an average degree of severity for deliveries with an adverse event.

We also conducted exploratory analyses regarding rotation of OP to OA position before delivery. Among labors with OP malposition that recorded a forceps rotation attempt, we calculated the proportion delivered in OP vs in OA position and examined the association of forceps rotation success with AOI score. Finally, we also explored the temporal trend in the rates of OP delivery modes.

Study variables
Study variables were selected from BCPDR variables, including those defined by the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Canada (ICD-10-CA) and the Canadian Classification of Health Interventions (CCI) codes, to include the maternal and neonatal components of the AOI, demographic information, potential confounders, fetal position in labor and at delivery, and mode of delivery (Appendix).

Statistical analysis
We calculated the incidence of OP malposition during labor and during delivery. We calculated the incidence of each mode of delivery and compared this distribution among OP vs OA positions at delivery (OP/OP vs combined OP/OA and OA/OA groups) using chi-square testing. Rates of OP CD mode were also examined for temporal trend.

We compared the AOI scores between the OP/OA (reference) and OP/OP position groups, using log-binomial logistic regression. We also compared the AOI scores for each of the 5 modes of delivery from OP malposition, using log-binomial logistic regression models and reporting crude and adjusted rate ratios (RR) with 95% confidence intervals (CIs). A multi-variable log-binomial logistic regression modeled the AOI score; exposure variables were position at delivery, delivery mode, and their interaction. We examined the following potential confounders in bivariable comparisons (using P<.05 as a criterion for addition to the model): length of second stage; use of epidural anesthesia; episiotomy; induction or augmentation of labor; previous neonatal...
death or stillbirth; birthweight of <2500 g or >4500 g; parity; gestational diabetes mellitus, gestational hypertension, or pre-existing diabetes mellitus; substance, alcohol, or tobacco use during pregnancy; prelabor rupture of membranes; fetal sex; maternal age; maternal height <163 cm; and obesity (prepregnancy body mass index >30 kg/m²).

RRs and 95% CIs for the rates of AOI subcomponents were compared between the OP/OA labor/delivery position group (reference) and the OP/OP group, and among OP delivery modes (with SVD as the reference), both using log-binomial logistic regression models. The WAOS and SI were compared among delivery modes using general linear models.

We calculated the success rate of forceps rotation from OP malposition and used multivariable log-binomial logistic regression analysis to assess the association between successful rotation and AOI, adjusted for potential confounders.

In addition, we compared demographic and clinical characteristics of women with and without information on fetal position in labor, using standardized differences.

Data were analyzed with R, version 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics for patient variables were presented as mean (with standard deviation) for continuous variables and frequency (percentage) for categorical variables. \( P < .05 \) was considered statistically significant.

Results

Of 555,886 term singleton deliveries, there were 165,894 (29.8%) with position in labor unknown or unspecified. Among the OP (n=64,582) and OA (n=248,138) positions in labor (a total of 312,720), there were 6483 deliveries (2.1%) with missing position at delivery. The resulting study population included 306,237 term births with 58,099 (19%) in OP position during labor. From OP position in labor, 36,601 (63%) turned to OA position for delivery (by any rotation method—spontaneously, manually, or with forceps), and 21,498 (37%) remained in OP at the time of delivery (Figure 1). Factors associated with persistent OP position included nulliparity, induction/augmentation, and prolonged second stage (Tables 1 and 2).

Mode of delivery differed significantly among women with persistent OP position (\( P < .0001 \)), who were less likely to deliver vaginally—either by SVD, forceps, or vacuum—but more likely to deliver by mixed vacuum-forceps (1%) or by CD (59%). The rates of OP/OP and OP/OA delivery are displayed in Figure 1; the distribution of delivery methods in the OA/OA delivery group was similar to that of the OP/OA group (83.3% SVD, 7.4% vacuum, 3.5% forceps, 0.4% forceps/vacuum, 5.4% CD). Temporal trends in OP delivery modes showed increasing rates of CD over time (Figure 2). Among cesarean OP deliveries, 66% occurred in the first stage and 34% in the second stage of labor.

Adverse outcome index scores

Adjusted for potential confounders, AOI scores, indicating the percentage of deliveries having \( \geq 1 \) adverse maternal or neonatal events, differed significantly between women with OP in labor and by final position at delivery (Table 3). The crude AOI scores were 9.0% and 8.8% for OP/OA (reference) and OP/OP deliveries, respectively; the adjusted RR was 1.07 (95% CI, 1.01–1.14).

The AOI scores also differed significantly by delivery mode (\( P < .0001 \)) within the OP/OP group. Among women with OP malposition at delivery, SVD and CD had the lowest AOI scores (ie, lowest chance of having any adverse outcome; 6.1% and 6.2%, respectively), followed by vacuum (14.6%), forceps (38.1%), and combined forceps and vacuum deliveries (35.9%) (Table 4). The most frequent AOI component outcomes were third- and fourth-degree tears (in vaginal deliveries only), and blood transfusions, NICU admissions, and low Apgar scores (Table 4).

The multivariable regression analysis of AOI score showed a significant interaction between position at delivery and delivery mode (\( P < .0001 \)) (Table 5; Figure 3), with a larger effect of delivery position on AOI score among forceps deliveries than among other modes of delivery. Each of the potential confounders were significantly associated with AOI in bivariable models, except previous neonatal death or stillbirth, substance use/alcohol/smoking, maternal age, and obesity.

Weighted Adverse Outcome Score and Severity Index

The WAOS (per-delivery average weighted score) and SI (average degree of severity for deliveries with an adverse event) differed significantly (both \( P < .0001 \)) across modes of OP delivery. The WAOS was highest in forceps and vacuum deliveries, whereas the SI was highest in CD; these scores were lowest in SVDs and forceps deliveries, respectively (Table 4).

Forceps rotation from occiput posterior to anterior

There were 3672 deliveries with forceps rotation attempts recorded (Figure 1). Of these, 1097 (30%) were unsuccessful and delivered by forceps (n=1095) or forceps and vacuum (n=2), whereas 2575 (70%) were successful and delivered by forceps (n=2571) or forceps and vacuum (n=4). Predictors of successful operative rotation included shorter second stage, absence of epidural, episiotomy, multiparity, female fetal sex, and younger maternal age in the multivariable model (Supplementary Table 1). Regardless of success, attempted forceps rotations had the highest AOI scores, and forceps-delivered OP deliveries had higher rates of blood transfusion, third- or fourth-degree tears, NICU admission, and birth trauma (Figure 3).

Women without information on position of labor were similar to women with such information; all standardized differences did not exceed 0.12 (Supplementary Table 2).

Comment

Principal findings

OP malposition is relatively common. In BC, 19% of term singleton deliveries had OP position in labor, and 37% of these—or 7% of all term singleton deliveries—had persistent OP position at
Persistent OP position deliveries in BC had a significantly different distribution of delivery modes compared with deliveries in OA position, with more frequent CD (59%) and mixed vacuum-forceps deliveries (1%). Overall AOI scores were significantly higher in women with persistent OP during delivery (8.8% had ≥1 adverse outcomes) than in those with OP/OA deliveries; neonatal adverse outcomes were also more frequent in the OP/OP group (4.3% vs 3.3%, respectively), whereas maternal outcomes were similar (4.8% vs 6.0%, respectively). Among persistent OP deliveries, SVD and CD had the lowest proportion of deliveries with ≥1 adverse outcomes (6.1% and 6.2%, respectively), whereas forceps deliveries had the highest proportion (38.1%). Among OP deliveries with an adverse outcome, the SI was highest in women with CD, although this reflects a higher severity score for outcomes including uterine rupture (which is associated with—but not a consequence of—CD) and ICU admission, and the absence of third- and fourth-degree tears that have been assigned a comparatively low score. Overall, delivery mode and the interaction between delivery mode and OP position were significant predictors of deliveries with ≥1 adverse outcomes, whereas OP position itself was not.

**Results in context**

Our study is consistent with previous research suggesting that persistent OP malposition and OVD are associated with adverse obstetrical events, most of which represent OASI. This is an expected association; compared with delivery from the OA position, the head’s deflexion from OP malposition, as the head emerges, more frequently leads to a higher AOI score for OP deliveries because of relatively frequent

---

* FIGURE 1: Flow diagram: management of occiput posterior labors in British Columbia

---

* Successful rotations, unspecified: includes spontaneous, manual, and forceps rotations (which may not have been coded specifically). These respective numbers cannot be delineated. Vacuum was not a rotational method attempted.
**Forceps rotations that were documented included: successful rotations followed by forceps delivery (n=2,571) or sequential forceps/vacuum delivery (n=4); and failed rotations followed by forceps (n=1,095) or by sequential forceps/vacuum delivery (n=2).
***Non rotations include: documented failed rotations, failed rotations that were attempted but not documented (manual or forceps), and deliveries in which no rotation from OP was attempted.

Foggin. Adverse birth outcomes following different occiput posterior delivery management methods. Am J Obstet Gynecol Glob Rep 2022.
| Characteristics                        | OA labor/OA delivery | OP labor/OA delivery | Standardized difference from OA | OP labor/OP delivery | Standardized difference from OA |
|----------------------------------------|----------------------|----------------------|---------------------------------|----------------------|---------------------------------|
| Age (y)                                |                      |                      |                                 |                      |                                 |
| Mean (SD)                              | 30.6 (±5.4)          | 30.4 (±5.3)          | 0.04                            | 30.4 (±5.4)          | 0.04                            |
| BMI (kg/m²)                            |                      |                      |                                 |                      |                                 |
| <18.5                                  | 12,406 (5.0)         | 1467 (4.0)           | 0.09                            | 751 (3.5)            | 0.17                            |
| 18.5—24.9                              | 115,443 (46.5)       | 17,389 (47.5)        | 9551                            | 3933 (18.3)          |                                 |
| 25—29.9                                | 35,599 (14.3)        | 6045 (16.5)          | 3800                            | 2280 (10.6)          |                                 |
| ≥30                                    | 19,777 (8.0)         | 3454 (9.4)           | 2280                            | 1080 (5.0)           |                                 |
| Missing                                | 64,913 (26.2)        | 8246 (22.5)          | 4883                            | 2322 (10.6)          |                                 |
| Parity                                 |                      |                      |                                 |                      |                                 |
| Nulliparous                            | 116,774 (47.0)       | 20,091 (54.9)        | 0.16                            | 15,381 (71.5)        | 0.52                            |
| Number of previous vaginal deliveries  |                      |                      |                                 |                      |                                 |
| 0                                      | 122,322 (49.3)       | 21,091 (57.6)        | 0.22                            | 15,613 (72.6)        | 0.64                            |
| ≥1                                     | 125,788 (50.7)       | 15,504 (42.4)        | 5883                            | 27.4                 |                                 |
| Number of previous cesarean deliveries |                      |                      |                                 |                      |                                 |
| 0                                      | 239,089 (86.4)       | 35,167 (96.1)        | 0.01                            | 21,139 (98.3)        | 0.013                           |
| ≥1                                     | 8993 (3.6)           | 1426 (3.9)           | 357                            | 1.6                  |                                 |
| Diabetes mellitus, gestational or preexisting |                |                      |                                 |                      |                                 |
| Yes                                    | 20,984 (8.5)         | 2953 (8.1)           | 0.01                            | 1951 (9.1)           | 0.02                            |
| Gestational hypertension               |                      |                      |                                 |                      |                                 |
| Yes                                    | 10,056 (4.1)         | 1563 (4.3)           | 0.01                            | 1339 (6.2)           | 0.1                             |
| Induction/augmentation                  |                      |                      |                                 |                      |                                 |
| Yes                                    | 144,261 (58.1)       | 26,045 (71.2)        | 0.28                            | 16,313 (75.9)        | 0.38                            |
| Epidural                               |                      |                      |                                 |                      |                                 |
| Yes                                    | 79,963 (32.2)        | 18,919 (51.7)        | 0.4                             | 13,926 (64.8)        | 0.69                            |
| Episiotomy                             |                      |                      |                                 |                      |                                 |
| Yes                                    | 24,199 (9.7)         | 4791 (13.1)          | 0.11                            | 2192 (10.2)          | 0.02                            |
| Second stage length (min)              |                      |                      |                                 |                      |                                 |
| Mean (SD)                              | 1.0 (±1.3)           | 1.4 (±1.5)           | 0.27                            | 2.2 (±2.0)           | 0.72                            |
| Missing                                | 11,009 (4.4)         | 820 (2.2)            | 8489                            | 39.5                 |                                 |
| Gestational age (wk)                   |                      |                      |                                 |                      |                                 |
| Mean (SD)                              | 38.8 (±1.7)          | 39.0 (±1.5)          | 0.12                            | 39.1 (±1.7)          | 0.18                            |
| Missing                                | 172 (0.1)            | 18 (0.0)             | 13                             | 0.1                  |                                 |
| Birthweight (g)                        |                      |                      |                                 |                      |                                 |
| <2500                                  | 2527 (1.0)           | 248 (0.7)            | 0.11                            | 127 (0.6)            | 0.2                             |
| 2500—2999                              | 30,106 (12.1)        | 3713 (10.1)          | 1922                           | 8.9                  |                                 |
| 3000—3499                              | 91,410 (36.8)        | 13,119 (35.8)        | 7183                           | 33.4                 |                                 |
| 3500—3999                              | 76,674 (30.9)        | 12,287 (33.6)        | 7388                           | 34.4                 |                                 |
| 4000—4499                              | 23,944 (9.6)         | 4215 (11.5)          | 2915                           | 13.6                 |                                 |
| ≥4500                                  | 3727 (1.5)           | 670 (1.8)            | 508                            | 2.4                  |                                 |
| Missing                                | 19,750 (8.0)         | 2349 (6.4)           | 1455                           | 6.8                  |                                 |

All comparisons are statistically significant, with P<.05.

BMI, body mass index; OA, occiput anterior; OP, occiput posterior; SD, standard deviation.

Foggin. Adverse birth outcomes following different occiput posterior delivery management methods. Am J Obstet Gynecol Glob Rep 2022.
| Characteristics | Spontaneous n=5727 | Vacuum n=1633 | Forceps n=1130 | Forceps and vacuum n=256 | Cesarean delivery n=12,752 |
|-----------------|-------------------|--------------|----------------|--------------------------|---------------------------|
| **Age (y)**     |                   |              |                |                          |                           |
| Mean (SD)       | 30.4 (±5.4)       | 29.7 (±5.6)  | 30.1 (±5.2)    | 29.5 (±5.7)              | 30.5 (±5.3)               |
| BMI             |                   |              |                |                          |                           |
| <18.5           | 187 (3.3)         | 82 (5.0)     | 48 (4.2)       | 14 (5.5)                 | 420 (3.3)                 |
| 18.5—24.9       | 2442 (42.6)       | 722 (44.2)   | 545 (48.2)     | 129 (50.4)               | 5713 (44.8)               |
| 25—29.9         | 972 (17.0)        | 248 (15.2)   | 179 (15.8)     | 38 (14.8)                | 2496 (19.6)               |
| ≥30             | 548 (9.6)         | 117 (7.2)    | 112 (9.9)      | 15 (5.9)                 | 1488 (11.7)               |
| Missing         | 1578 (27.6)       | 464 (28.4)   | 246 (21.8)     | 60 (23.4)                | 2635 (20.7)               |
| **Parity**      |                   |              |                |                          |                           |
| Nulliparous     | 1881 (32.8)       | 948 (58.1)   | 857 (75.8)     | 188 (73.4)               | 11,507 (90.2)             |
| Number of previous vaginal deliveries |                   |              |                |                          |                           |
| 0               | 1993 (34.8)       | 1010 (61.8)  | 909 (80.4)     | 194 (75.8)               | 11,507 (90.2)             |
| ≥1              | 3732 (65.2)       | 623 (38.1)   | 221 (19.5)     | 62 (24.2)                | 1245 (9.8)                |
| Number of previous cesarean deliveries |                   |              |                |                          |                           |
| 0               | 5534 (96.6)       | 1536 (94.1)  | 1070 (94.7)    | 247 (96.5)               | 12,752 (100.0)            |
| ≥1              | 191 (3.4)         | 97 (5.9)     | 60 (5.3)       | 9 (3.5)                  | 0 (0.0)                   |
| Diabetes mellitus, gestational or preexisting |                   |              |                |                          |                           |
| 403 (7.0)       | 126 (7.7)         | 94 (8.3)     | 16 (6.2)       | 1312 (10.3)              |
| Gestational hypertension |                   |              |                |                          |                           |
| 185 (3.2)       | 82 (5.0)          | 70 (6.2)     | 18 (7.0)       | 984 (7.7)                |
| Induction/augmentation |                   |              |                |                          |                           |
| 3474 (60.7)     | 1195 (73.2)       | 871 (77.1)   | 204 (79.7)     | 10,569 (82.9)            |
| Episiotomy      |                   |              |                |                          |                           |
| 1879 (32.8)     | 822 (50.3)        | 887 (78.5)   | 165 (64.5)     | 10,173 (79.8)            |
| Second stage length (min) |                   |              |                |                          |                           |
| Mean (SD)       | 1.0 (±1.0)        | 1.8 (±1.6)   | 2.6 (±2.0)     | 2.2 (±1.5)               | 3.8 (±1.9)                |
| Missing         | 42 (0.7)          | 13 (0.8)     | 25 (2.2)       | 2 (0.8)                  | 8407 (65.9)               |
| Gestational age (wk) |                   |              |                |                          |                           |
| Mean (SD)       | 38.7 (±2.1)       | 38.9 (±1.5)  | 38.8 (±1.9)    | 39.1 (±1.4)              | 39.4 (±1.4)               |
| Missing         | 4 (0.1)           | 0 (0)        | 0 (0)          | 1 (0.4)                  | 8 (0.1)                   |
| Birthweight (g) |                   |              |                |                          |                           |
| <2500           | 50 (0.9)          | 16 (1.0)     | 9 (0.8)        | 2 (0.8)                  | 50 (0.4)                  |
| 2500—2999       | 602 (10.5)        | 219 (13.4)   | 144 (12.7)     | 22 (8.6)                 | 935 (7.3)                 |
| 3000—3499       | 2040 (35.6)       | 622 (38.1)   | 420 (37.2)     | 92 (35.9)                | 4009 (31.4)               |
| 3500—3999       | 1804 (31.5)       | 484 (30.3)   | 321 (28.4)     | 89 (34.8)                | 4680 (36.7)               |
| 4000—4499       | 576 (10.1)        | 140 (8.6)    | 97 (8.6)       | 34 (13.3)                | 2068 (16.2)               |
| ≥4500           | 91 (1.6)          | 23 (1.4)     | 16 (1.4)       | 1 (0.4)                  | 377 (3.0)                 |
| Missing         | 564 (9.6)         | 119 (7.3)    | 123 (10.9)     | 16 (6.2)                 | 633 (5.0)                 |

All comparisons are statistically significant at P<0.05.

BMI, body mass index; OP, occiput posterior; SD, standard deviation.

Foggin. Adverse birth outcomes following different occiput posterior delivery management methods. Am J Obstet Gynecol Glob Rep 2022.
OASIs. The lower SI is thus expected in OP vaginal deliveries with OASIs because OASI was assigned a score of least severity (5). The association of OASIs with OP OVDs is especially important to note in the Canadian population, where higher rates of OVD have recently been described\(^2\): among term singleton deliveries without previous CD, 11.3% were attempted OVDs, including 2.9% attempted forceps and 8.4% attempted vacuum deliveries, with 6.1% of vacuum deliveries followed by attempted sequential forceps use.\(^2\) In our study, persistent OP position was not associated with OASI, with similarly low rates in OP/OP and OP/OA deliveries (3.6% and 5.1%, respectively; adjusted RR, 1.01 [0.92–1.10]), which contrasts with literature showing that rotated OP to OA position has lower risk of OASI than nonrotated OP/OP (24.3% vs 43.4%, respectively).\(^3\) This discrepancy is likely because of the high rate of CD in the OP/OP delivery group in our study. CD avoids OASIs, thus the rate of OASI in the OP/OP group was reduced compared with the OP/OP group that had a lower rate of CD. The increasing CD rate in OP deliveries over time in BC (Figure 2) may suggest that the increasing recognition of lower rates of OASI with CD by maternity care providers has led to gradual changes in obstetrical practice; it may also represent other regional differences leading to higher rates of CD in our population (eg, higher proportion of women aged ≥35 years). Our results pertaining to length of the second stage of labor and need for blood transfusion are consistent with previous studies showing an association of OP malposition with prolonged labor and postpartum hemorrhage.\(^6,8\)

**Clinical implications**

This study presents information on term, singleton OP deliveries in BC and their management and outcomes, providing an updated overview of mode of delivery and adverse outcomes for maternity care providers. Our findings also provide information useful for counseling patients, should time and resources allow discussion of multiple delivery modes.

Confounding by indication is possible and may prevent conclusive recommendations for management of persistent OP position. However, because most OP positions in labor were successfully rotated to OA position by delivery, and most (77%) of the OP/OA deliveries were by SVD (which had the lowest AOI rates), our findings suggest that monitoring OP positions for spontaneous rotation and pursuing manual rotation (if spontaneous rotation does not occur) may be worthwhile. This is supported in part by a recent systematic review and meta-analysis of literature regarding manual rotation of OP and occiput transverse positions, compared with expectant management. This review found a significant increase in rates of SVD with manual rotation, in the absence of discrepant rates of CD and OVD, and without increases in adverse maternal and neonatal outcomes.\(^2\) Previous literature shows that an estimated 15%\(^2\) of OP fetuses spontaneously rotate, and that 60% to 90% of attempted manual rotations are successful.\(^2,3\)

Among women with OP position in labor that is not successfully rotated spontaneously or manually, management options include an attempt of forceps rotation, vaginal delivery (with or without instruments) from OP position, or CD. In our exploratory analysis of documented forceps rotation attempts (n=3672), 70% of attempted rotations were successful (Supplementary Table 1). However, this analysis was limited because forceps rotation was documented only when the rotation attempt was followed by successful forceps delivery (ie, not including attempts at forceps rotation followed by a failed forceps delivery that proceeded with CD). Among women with OP position at delivery, overall adverse outcome rates were highest in deliveries by forceps (38.1%), and lowest in SVD (6.1%) and CD (6.2%). We could not determine delivery mode failure rates in cases of successive delivery mode attempts, but in a previous study, vacuum-assisted and forceps-assisted deliveries failed in 33% and 14% of OP deliveries, respectively.\(^3\)

**Research implications**

Future research directions include: (1) examining the success and failure rates of rotation and delivery attempts, which will help further inform OP management pathways; (2) comparing the rates, costs, and morbidities of long-term consequences of various delivery modes in the management of OP position (eg, long-term outcomes related to OASI vs repeated CD); and (3) consistent collection of information regarding manual and forceps rotation attempts in population databases (eg, perinatal and birth registries).

**Strengths and limitations**

The strengths of this study include a large population database with detailed
| Outcomes                          | OA labor/OA delivery n=248,138 | OP labor/OA delivery (reference) n=36,601 | OP labor/OP delivery (OP/OP) n=21,498 | OP/OP RR (95% CI) | OP/OP aRR (95% CI) |
|----------------------------------|--------------------------------|-------------------------------------------|----------------------------------------|------------------|------------------|
| AOI                              | 17,609 (7.1)                   | 3312 (9.0)                                | 1896 (8.8)                             | 0.97 (0.92−1.03) | 1.07 (1.01−1.14) |
| WAOS, mean (SD)                  | 1.5 (9.9)                      | 1.9 (11.0)                                | 2.4 (13.1)                             | 2.18 (1.99−2.37) | 2.18 (1.99−2.37) |
| SI, mean (SD)                    | 21.5 (30.9)                    | 21.3 (30.5)                               | 27.5 (35.5)                            | 24.14 (22.49−27.78) | 24.14 (22.49−27.78) |
| Maternal AOI                     | 11,769 (4.7)                   | 2202 (6.0)                                | 1042 (4.8)                             | 0.81 (0.75−0.87) | 1.04 (0.96−1.13) |
| Maternal death                   | 0 (0.0)                        | 0 (0.0)                                   | 0 (0.0)                                | —                | —                |
| Uterine rupture                  | 30 (0.01)                      | <5                                        | 25 (0.12)                              | —                | —                |
| ICU admission                    | 66 (0.03)                      | 16 (0.04)                                 | 22 (0.10)                              | 2.34 (1.24−4.53) | 1.70 (0.57−4.72) |
| Unexpected operation             | 1372 (0.6)                     | 208 (0.6)                                 | 88 (0.4)                               | 0.72 (0.56−0.92) | 0.78 (0.56−1.06) |
| Blood transfusion                | 1346 (0.5)                     | 206 (0.6)                                 | 196 (0.9)                              | 1.62 (1.33−1.97) | 1.68 (1.33−2.13) |
| Third- or fourth-degree tear     | 9542 (3.8)                     | 1868 (5.1)                                | 785 (3.6)                              | 0.72 (0.66−0.78) | 1.01 (0.92−1.10) |
| Neonatal AOI                     | 6257 (2.5)                     | 1195 (3.3)                                | 916 (4.3)                              | 1.31 (1.20−1.42) | 1.21 (1.10−1.35) |
| Neonatal death or stillbirth     | 64 (0.03)                      | 11 (0.03)                                 | 9 (0.04)                               | 1.39 (0.56−3.65) | 1.04 (0.28−3.11) |
| NICU admission >24 h             | 3170 (1.3)                     | 593 (1.6)                                 | 531 (2.5)                              | 1.52 (1.36−1.71) | 1.35 (1.17−1.56) |
| Apgar at 5 min <7               | 3252 (1.3)                     | 625 (1.7)                                 | 427 (2.0)                              | 1.16 (1.03−1.31) | 1.14 (0.98−1.32) |
| Birth trauma                     | 412 (0.2)                      | 109 (0.3)                                 | 65 (0.3)                               | 1.02 (0.74−1.38) | 1.32 (0.94−1.84) |

AOI, adverse outcome index; aRR, adjusted rate ratio; BMI, body mass index; CI, confidence interval; ICU, intensive care unit; NICU, neonatal intensive care unit; OA, occiput anterior; OP, occiput posterior; RR, rate ratio; SD, standard deviation; SI, Severity Index; WAOS, Weighted Adverse Outcome Score.

* Adjusted for duration of second stage, epidural use, episiotomy, induction and/or augmentation of labor, birthweight <2500 g or >4500 g, parity, diabetes mellitus and/or hypertension, premature rupture of membranes, and sex of neonate.; † Marginal means and 95% CI.

Foggin. Adverse birth outcomes following different occiput posterior delivery management methods. Am J Obstet Gynecol Glob Rep 2022.
### Table 4

Labor and delivery outcomes by mode of delivery for occiput posterior labor—occiput posterior delivery group

| Outcome                      | SVD (reference) | Vacuum | RR (95% CI) | aRR (95% CI)* | Forceps | RR (95% CI) | aRR (95% CI)* | Forceps and vacuum | Cesarean delivery | RR (95% CI) | aRR (95% CI)* |
|------------------------------|-----------------|--------|-------------|---------------|---------|-------------|---------------|-------------------|------------------|-------------|---------------|
| AOh                          | 347 (6.1)       | 238 (14.6) | 2.41 (2.24–2.59) | 1.96 (1.79–2.14) | 430 (38.1) | 4.50 (4.22–4.81) | 3.35 (3.04–3.69) | 92 (35.9) | 5.00 (4.40–5.64) | 3.62 (3.06–4.26) | 789 (6.2) | 0.98 (0.91–1.06) | 0.89 (0.78–1.01) |
| WAOS, mean (SD)              | 1.6 (13.2)      | 2.5 (9.5)  | 2.77 (2.45–3.09)   | 5.4 (13.6) | 3.75 (3.31–4.18) | 6.4 (29.6) | 5.48 (4.51–6.46) | 2.4 (12.9) | 2.88 (2.50–3.27) |
| SI, mean (SD)                | 25.6 (47.5)     | 17.4 (18.9) | 19.57 (17.51–21.63) | 14.3 (19.0) | 14.64 (12.58–16.70) | 17.8 (47.5) | 19.53 (15.01–24.06) | 39.6 (34.7) | 41.34 (38.01–44.66) |
| Maternal AOh                 | 225 (3.9)       | 179 (11.0) | 2.73 (2.49–2.99)   | 2.26 (2.03–2.52) | 374 (33.1) | 6.41 (5.94–6.92) | 5.01 (4.48–5.61) | 82 (32.0) | 7.13 (6.18–8.17) | 5.35 (4.44–6.41) | 182 (1.4) | 0.38 (0.33–0.44) | 0.43 (0.34–0.53) |
| Maternal death               | 0 (0.0)         | 0 (0.0)   | —             | —             | 0 (0.0) | —             | —             | 0 (0.0) | —             | —             | —             | —             |
| Uterine rupture              | <5              | <5        | —             | —             | <5    | —             | —             | <5    | —             | —             | —             | —             |
| ICU admission                | <5              | <5        | —             | —             | <5    | —             | —             | <5    | —             | —             | —             | —             |
| Unexpected operation         | 28 (0.5)        | 12 (0.7)  | 1.60 (1.15–2.19) | 1.60 (1.08–2.33) | 8 (0.7) | 1.78 (1.22–2.56) | 1.91 (1.16–3.05) | <5    | 2.32 (0.99–4.54) | 2.04 (0.71–4.66) | 36 (0.3) | 0.59 (0.42–0.83) | 0.91 (0.51–1.56) |
| Blood transfusion            | 20 (0.3)        | 17 (1.0)  | 2.26 (1.62–3.11) | 1.96 (1.33–2.85) | 25 (2.2) | 5.11 (3.82–6.79) | 4.31 (2.90–6.35) | <5    | 5.26 (2.77–9.06) | 5.16 (2.62–9.34) | 130 (1.0) | 2.71 (2.13–3.44) | 4.16 (2.89–5.99) |
| Third- or fourth-degree tear | 186 (3.2)       | 159 (9.7) | 2.93 (2.65–3.24) | 2.35 (2.09–2.64) | 361 (31.9) | 7.28 (6.70–7.91) | 5.49 (4.87–6.19) | 79 (30.9) | 8.13 (6.99–9.38) | 5.88 (4.84–7.09) | 0 (0.0) | —             | —             |
| Neonatal AOh                 | 134 (2.3)       | 70 (4.3)  | 2.01 (1.77–2.27) | 1.57 (1.36–1.80) | 79 (7.0) | 1.99 (1.71–2.38) | 1.41 (1.18–1.69) | 15 (5.9) | 2.38 (1.70–3.20) | 1.69 (1.19–2.32) | 618 (4.8) | 1.86 (1.68–2.05) | 1.64 (1.39–1.93) |
| Neonatal death or stillbirth | <5              | <5        | —             | —             | <5    | —             | —             | <5    | —             | —             | —             | —             |
| NICU admission >24 h          | 58 (1.0)        | 33 (2.0)  | 1.80 (1.48–2.17) | 1.43 (1.15–1.75) | 43 (3.8) | 2.18 (1.78–2.67) | 1.59 (1.22–2.05) | <5    | 2.04 (1.19–3.22) | 1.41 (0.80–2.30) | 393 (3.1) | 2.40 (2.10–2.73) | 2.50 (2.00–3.12) |
| Apgar at 5 min <7            | 77 (1.3)        | 50 (3.1)  | 2.12 (1.78–2.50) | 1.66 (1.37–2.01) | 28 (2.5) | 1.56 (1.23–1.94) | 1.09 (0.82–1.42) | 9 (0.5) | 1.95 (1.16–3.03) | 1.46 (0.86–2.32) | 263 (2.1) | 1.45 (1.25–1.67) | 1.17 (0.87–1.43) |
| Birth trauma                 | 10 (0.2)        | <5        | 3.59 (2.32–5.48) | 2.77 (1.72–4.41) | 21 (1.9) | 6.05 (3.96–9.14) | 3.93 (2.32–6.61) | <5    | 13.31 (8.99–23.46) | 8.65 (4.27–16.40) | 29 (0.2) | 1.61 (1.05–2.45) | 2.24 (1.24–3.97) |

AOh, adverse outcome index; aRR, adjusted rate ratio; CI, confidence interval; ICU, intensive care unit; NICU, neonatal intensive care unit; RR, rate ratio; SD, standard deviation; SI, Severity Index; SVD, spontaneous vaginal delivery; WAOS, Weighted Adverse Outcome Score.

* Adjusted for duration of second stage, epidural use, episiotomy, induction and/or augmentation of labor, birthweight <2500 g or >4500 g, parity, diabetes mellitus and/or hypertension, premature rupture of membranes, and sex of neonate; ** Marginal means and 95% CI.

Foggin. Adverse birth outcomes following different occiput posterior delivery management methods. Am J Obstet Gynecol Glob Rep 2022.
data collection. Compared with hospitalization-based studies, selection bias is minimized by using population data. Generalizability is larger because the data are drawn from the spectrum of settings, healthcare resources, practices, and demographic groups. A validation study showed an excellent overall validity of the BCPDR data, including information on fetal position; OA position in labor had sensitivity of 89.8% and specificity of 90.8%; OP position in labor had a bit lower sensitivity of 66.9% and specificity of 98.5%; OA position at delivery had sensitivity of 96.5% and specificity of 88.6%; and OP position at delivery had sensitivity of 78.6% and specificity of 99.0%.17

Limitations include the observational nature of the study with residual confounding by indication and limitations of the dataset. We mitigated confounding by indication by adjustment for confounders related to OVD and CD indications in the analyses. The relatively high rate of CD in our study may have implications for generalizability to settings with low rates of CD. However, high OVD rates in settings with low CD rates may result in overall higher rates of OASI in women with OP position in labor. The reasons behind the high CD rates in our study are unknown; it may be related to clinicians’ proclivity to proceed with CD before progress to full dilation in women with OP in labor, which ultimately avoids OVD.

The advantages of the composite AOI include the inclusion of a broad range of important adverse outcomes, standardization, and increased statistical power to provide robust comparisons. However, as a composite outcome, the AOI lacks specificity for associations of risk factors and individual components of the composite outcome, which requires further analyses. Some components of the AOI are not relevant to all delivery modes; for example, uterine rupture is associated with CD (but is an indication for CD rather than its outcome). The WAOS and the SI also have some limitations. The fact that forceps and vacuum deliveries had the highest AOI and WAOS, but CD had the highest SI, reflects that weight assignments are based on expert opinion and may be subject to bias. The selected composite outcomes and weights seem to be focused on short-term outcomes. For example, perineal tears are rapidly repaired after delivery and have low severity weights (score of 5) but can have long-term pelvic floor consequences (eg, urinary and fecal/anal incontinence and pelvic organ prolapse), whereas heavily weighted ICU admissions (score of 65) or blood transfusions (score of 20) are more acute, transient outcomes. Long-term outcomes are important considerations in CD as well, including increased rates of repeated CD with associated risks (eg, uterine rupture, placenta previa, and placenta accreta).

**Conclusion**

In BC, Canada, 19% of term singleton deliveries had OP position in labor, and 37% of these persisted in OP position at delivery (7% overall). Persistent OP
malposition was delivered in 59% of cases by CD, in 27% by SVD, in 8% by vacuum, in 5% by forceps, and in 1% by mixed VFD. Inclusive of third- or fourth-degree lacerations, CD and SVD had the lowest proportion of deliveries with adverse outcomes (6.2% and 6.1%), compared with vacuum, forceps, and mixed vacuum-forceps deliveries (14.6%, 38.1%, and 35.9%, respectively). OP deliveries had higher rates of overall and neonatal adverse outcomes, and similar rates of maternal adverse outcomes compared with OA deliveries. The interaction between delivery mode and OP position was also a significant predictor of deliveries with ≥1 adverse outcomes. Although this study does not provide a clear recommendation for delivery management of OP malposition (because of its observational nature), it does provide a robust, updated overview of adverse outcomes to inform provider decision-making and counseling. We also recommend future research directions to inform OP management pathways, including examining failure rates of rotation and delivery attempts, and comparing long-term consequences of persistent OP delivery methods.

ACKNOWLEDGMENTS
The authors thank Perinatal Services BC for providing the 2004-2020 data extract from the British Columbia Perinatal Data Registry in 2021.

Supplementary materials
Supplementary material associated with this article can be found in the online version at doi:10.1016/j.xagr.2022.100080.

REFERENCES
1. Cheng YW, Shaffer BL, Caughey AB. Associated factors and outcomes of persistent occiput posterior position: a retrospective cohort study from 1976 to 2001. J Matern Fetal Neonatal Med 2006;19:563–8.
2. Fitzpatrick M, McQuillan K, O’Herlihy C. Influence of persistent occiput posterior position on delivery outcome. Obstet Gynecol 2001;98:1027–31.
3. Ponkey SE, Cohen AP, Heffner LJ, Lieberman E. Persistent fetal occiput posterior position: obstetric outcomes. Obstet Gynecol 2003;101:915–20.
4. Cheng YW, Shaffer BL, Caughey AB. The association between persistent occiput posterior position and neonatal outcomes. Obstet Gynecol 2006;107:837–44.
5. Eggebo TM, Helen C, Økland I, et al. Prediction of labour and delivery by ascertaining the fetal head position with transabdominal ultrasound in pregnancies with prelabour rupture of membranes after 37 weeks. Ultrasound Med 2008;29:179–83.
6. Cheng YW, Hubbard A, Caughey AB, Tager IB. The association between persistent fetal occiput posterior position and perinatal outcomes: an example of propensity score and covariate distance matching. Am J Epidemiol 2010;171:656–63.
7. Dahlgqvist K, Jonsson M. Neonatal outcomes of deliveries in occiput posterior position when delayed pushing is practiced: a cohort study. BMC Pregnancy Childbirth 2017;17:377.
8. Gardberg M, Tuppurainen M. Persistent occiput posterior presentation—a clinical problem. Acta Obstet Gynecol Scand 1994;73:45–7.
9. Senecal J, Xiong X, Fraser WD. Pushing Early Or Pushing Late with Epidural study group. Effect of fetal position on second-stage duration and labor outcome. Obstet Gynecol 2005;105:763–72.
10. Yagel O, Cohen SM, Lipschultz M, et al. Higher rates of operative delivery and maternal and neonatal complications in persistent occiput posterior position with a large head circumference: a retrospective cohort study. Fetal Diagn Ther 2018;44:51–8.
11. Damron DP, Capeless EL. Operative vaginal delivery: a comparison of forceps and vacuum for success rate and risk of rectal sphincter injury. Am J Obstet Gynecol 2004;191:907–10.
12. Benavides L, Wu JM, Hundley AF, Ivester TS, Visco AG. The impact of occiput posterior fetal head position on the risk of anal sphincter injury in forceps-assisted vaginal deliveries. Am J Obstet Gynecol 2005;192:1702–6.
13. Wu JM, Williams KS, Hundley AF, Connolly AM, Visco AG. Occiput posterior fetal head position increases the risk of anal sphincter injury in vacuum-assisted deliveries. Am J Obstet Gynecol 2005;193:525–8.
14. Ashwal E, Wertheimer A, Aviram A, et al. The association between fetal head position prior to vacuum extraction and pregnancy outcome. Arch Gynecol Obstet 2016;293:567–73.
15. Bradley MS, Kaminski RJ, Streitman DC, Dunn SL, Krans EE. Effect of rotation on perineal lacerations in forceps-assisted vaginal deliveries. Obstet Gynecol 2013;122:132–7.
16. Sen K, Sakamoto H, Nakabayashi Y, et al. Management of the occiput posterior presentation: a single institute experience. J Obstet Gynaecol Res 2013;39:160–5.
17. Frooss G, Hutcheon J, Joseph KS, Kinniburgh B, Johnson C, Lee L. Validating the British Columbia Perinatal Data Registry: a chart re-abstraction study. BMC Pregnancy Childbirth 2015;15:123.
18. Women’s Health Research Institute. Updates on the BC Perinatal Data Registry. 2021. Available at: https://whri.org/uploads-on-the-bc-perinatal-data-registry/. Accessed May 3, 2021.
19. R Core Team. R: A Language and Environment for Statistical Computing. 2020. Available at: https://www.r-project.org/. Accessed August 27, 2021.
20. Muraca GM, Boutin A, Razaz N, et al. Maternal and neonatal trauma following operative vaginal delivery. CMAJ 2022;194:E1–12.
21. Bertholdt C, Morel O, Zuily S, Ambroise-Grandjean G. Manual rotation of occiput posterior or transverse positions: a systematic review and meta-analysis of randomized controlled trials. Am J Obstet Gynecol 2022;226:781–93.
22. Reichman O, Gdansky E, Latinsky B, Labi S, Samueloff A. Digital rotation from occipito-posterior to occipito-anterior decreases the need for cesarean section. Eur J Obstet Gynecol Reprod Biol 2008;136:25–8.
23. Bertholdt C, Piffer A, Pol H, Morel O, Guerby P. Management of persistent occiput posterior position: the added value of manual rotation. Int J Gynaecol Obstet 2022;157:613–7.
24. Le Ray C, Serres P, Schmitz T, Cabrol D, Goffinet F. Manual rotation in occiput posterior or transverse positions: risk factors and consequences on the cesarean delivery rate. Obstet Gynecol 2007;110:873–9.