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Neonatal Outcomes of Water Delivery versus Land Delivery: A Retrospective Propensity Score Weighted Study

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Abstract

Objective Recent evidence has shown that water delivery is safe for the mother, but high-quality evidence is not available for the newborn. Therefore, obstetric guidelines do not support it. This retrospective study aimed to contribute to the available evidence on maternal and neonatal outcomes associated with water delivery.

Study Design Retrospective cohort study from prospectively collected birth registry data from 2015 to 2019. A total of 144 consecutive water deliveries and 265 land deliveries eligible for waterbirth were identified. The inverse probability of treatment weighting (IPTW) method was applied to address for confounders.

Results We identified 144 women who delivered in water (water group) and 265 women who delivered on land (land group). One (0.7%) neonatal death was observed in the water delivery group. After IPTW adjustment, water delivery was significantly associated with a higher risk of maternal fever in puerperium (odds ratio [OR]: 4.98; 95% confidence interval [CI]: 1.86–17.02; $p = 0.004$), of neonatal cord avulsion (OR: 20.73; 95% CI: 2.63–2,674; $p = 0.001$), and of positive neonatal C-reactive protein (CRP > 5 mg/L; OR: 2.59; 95% CI: 1.05–7.24; $p = 0.039$); delivering in water was associated with lower maternal blood loss (mean difference: 110.40 mL; 95% CI: 191.01–29.78; $p = 0.007$), a lower risk of major (≥1,000 mL) postpartum hemorrhage (OR: 0.96; 95% CI: 0.92–0.99; $p = 0.016$), lower risk of manual placenta delivery (OR: 0.18; 95% CI: 0.03–0.67; $p = 0.008$) and curettage (OR: 0.24; 95% CI: 0.08–0.60; $p = 0.002$), lower use of episiotomy (OR: 0.02; 95% CI: 0–0.12; $p < 0.001$), and lower risk of neonatal ward admission (OR: 0.35; 95% CI: 0.25–0.48; $p < 0.001$).

Conclusion The present study showed that differences are present between water and land delivery, and among them is the risk of cord avulsion, a severe and potentially fatal event. In women choosing to deliver in water, a trained staff must be present and immediate recognition of cord avulsion is key for a prompt management to avoid possible serious complications.

Keywords

- cord avulsion
- cord rupture
- maternal outcomes
- neonatal outcomes
- safety
- water labor

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Key Points

- High-quality evidence is not available for neonatal safety of waterbirth; therefore, retrospective studies still represent the main body of evidence.
- Differences are present between water and land delivery, and among them, the increased risk of cord avulsion is a potentially fatal event.
- A trained staff must assist women who chose to deliver in water and cord avulsion must be promptly recognized and managed to avoid severe neonatal complications.

Water immersion during labor has been known for centuries, and its positive effects historically reported. First described in 1805,[1] the use of water during labor gathered momentum in the 1990s[2,3] and remains popular even today.[4] Water immersion during the first stage of labor has been extensively associated with benefits in terms of pain control and length of labor,[5–10] and societies generally accept it as safe for neonates and beneficial to mothers.[11,12] The same conclusions cannot be driven for water immersion during the second stage and delivery. Although recent evidence has shown that waterbirth is associated with a lower risk of negative maternal outcomes, such as postpartum hemorrhage and perineal tears[6,10,13–16] and some studies have reported no increased risk of neonatal intensive care unit (NICU) admission,[13,14,17,18] the safety of water delivery for the newborn remains a question of concern given the insufficient high-quality data. Consequently, professional societies either do not recommend or discourage the delivery of the fetus in water.[8,11,12,19]

Few randomized controlled trials (RCTs) for waterbirth have been performed so far.[7,8,20,21] Given that randomizing patients to the mode of delivery may not be ethical, patients may be unwilling to participate and blinding is not possible.[22,23] Additionally, RCTs may not detect rare adverse outcomes associated with waterbirth (e.g., cord avulsion, water aspiration) if powered for more frequent events.[13,14,24–32] Therefore, observational studies represent an important source of evidence.

This study aims to contribute to the body of knowledge about the risks and benefits of waterbirth compared with land birth. We investigated maternal and neonatal outcomes of women who delivered in water at our institution.

Materials and Methods

Study Population

This retrospective study was conducted at the Division of Obstetrics and Gynecology, Department of Maternal, Neonatal and Infant Medicine, ASL Biella, Biella, Italy. We retrieved and reviewed the prospectively completed birth registry data from April 1, 2015 to October 31, 2019.

After excluding women who had cesarean sections and operative vaginal delivery, we identified and included all pregnant women who delivered in water as the exposed group. Waterbirth was defined as a vaginal delivery with the newborn delivered in water, regardless of the stage of labor when water immersion began. The unexposed group was identified by selecting women who delivered on land and would have been eligible for water delivery.

According to the institutional waterbirth protocol, eligibility for water delivery was based on the inclusion and exclusion criteria reported in ►Table 1. Women were allowed to enter the pool if in active I stage of labor (defined by the presence of regular uterine contractions with cervical dilatation ≥ 4 cm) and if cardiotocography (CTG) tracing was reassuring.[33] Demographic, pregnancy, and labor characteristics, delivery outcomes, and puerperium characteristics were extracted from the birth registry and medical records by trained physicians. Neonatal files were also checked to collect data on neonatal outcomes. Fever during labor or in

Table 1 Inclusion and exclusion criteria for water labor and delivery according to the institution's protocol

Inclusion criteria	Exclusion criteria
• Singleton pregnancy with cephalic fetal presentation • Gestational age between 37^{+0} and 41^{+6} weeks' gestations (ultrasound confirmed) • Intact membranes or rupture of membranes for less than 24 h and with clear amniotic fluid • Estimated fetal weight between 2,500 and 4,000 g • Regular placenta insertion • Absence of intrapartum risk factors (intrapartum hemorrhage, fever, epidural analgesia, uterine hypertone) • Availability of 1:1 mother-to-midwife care	• Presence of at least one of fetal or maternal conditions requiring continuous CTG monitoring[a] • Presence of vulvar condylomatosis • Presence of bleeding or purulent skin lesions • Presence of maternal conditions making it difficult for the mother to get in and out of the pool autonomously • Maternal BMI ≥ 35 kg/m^2

Abbreviations: BMI, body mass index; CTG, cardiotocography; DBP, diastolic blood pressure; SBP, systolic blood pressure.

[a]Continuous CTG monitoring if ≥ 1 of the major criteria or ≥ 2 of the minor criteria were present. Major criteria: suspect of chorioamnionitis (ref. for criteria) or temperature ≥38°C; severe hypertension (SBP ≥ 160 mm Hg and/or DBP ≥ 110 mm Hg); use of intravenous oxytocin; meconium-stained amniotic fluid (moderate or thick meconium); vaginal bleeding. Minor criteria: premature rupture of the membranes lasting > 24 h; hypertension with SBP 140 to 159 mm Hg and/or DBP 90 to 109 mm Hg; protracted I or II stage of labor; thin meconium-stained amniotic fluid.

the postpartum was defined as maternal body temperature ≥37.5°C. Postpartum blood loss was estimated with V-drapes with calibrated pockets after the delivery of the baby. Women who delivered in water were helped to exit the pool immediately after delivery to favor an accurate blood loss measurement. If a subjectively relevant blood loss was observed immediately after neonatal birth in water, the amount of estimated blood loss while in the pool was added to the total final estimation. After delivery, neonates were kept with the mother or admitted to the neonatal ward for observation if criteria were met (e.g., mild respiratory distress, late preterm, neonatal jaundice, neonatal hypoglycemia). If neonates needed admission to NICU, they were transferred to a third level center.

Water Delivery

Tap warm water (comfortable for the woman and not above 37.5°C) was used to fill the pool and was changed if contaminated with body fluids. The room temperature was set at 22°C. During water immersion, one-to-one midwife assistance was mandatory. Entonox (nitrous oxide gas) was available and used for pain control, whereas opioid analgesia contraindicated water immersion for at least 2 hours after administration. Maternal vital signs (blood pressure, heart rate, and body temperature) were checked hourly. Intermittent auscultation of the fetal heart was performed every 15 minutes for 1 minute after contraction during the first stage and every 5 minutes for 1 minute after contraction during the second stage. The obstetric examination was performed every 2 to 4 hours and every 1 hour during the first and second stage, respectively. After water delivery, the cord was immediately clamped, and the third stage of labor was assisted outside the pool for accurate blood loss evaluation. The mother had to exit the pool if any safety concerns. Skin-to-skin was proposed to every woman. A neonatologist was called and was available in the delivery room at birth.

Statistical Analysis

The Kolmogorov–Smirnov test and visual plot inspection were used to assess the normality of data distribution. Categorical variables were summarized as proportions, whereas continuous variables were summarized as medians and interquartile ranges or means and standard deviations. Differences in proportions were assessed with a Chi-square or a Fisher's exact test, whereas continuous data were compared between two groups with an independent *t*-test. Kruskal–Wallis test by ranks was used to compare nonparametric continuous and ordinal variables. Odds ratios (ORs) and 95% confidence intervals (CI) were estimated for comparisons. In case of frequency = 0 in one of the categories, Firth's correction was used to estimate the OR. Due to potential imbalances between the two groups, we implemented the inverse probability of treatment weighting (IPTW) to address possible selection biases for the ORs estimation, being patients not randomly assigned to the mode of delivery. We estimated propensity scores including the following variables: maternal age, maternal body mass index, foreign origin, smoking status, gestational diabetes mellitus, oligohydramnios, gestational age at delivery, rectovaginal colonization with Group B Streptococcus, induction of labor, length of I stage and II stage of labor, labor augmentation, fever in labor, and the use of labor analgesia (any type). Propensity scores were used to generate the weights included in the weighted logistic regression analysis for the outcomes of interest. Weights were the reciprocal of the probability (propensity score) of receiving the treatment that was received. All reported *p*-values were two-sided, and significance was considered at $p < 0.05$. Data analyses were performed using R and IBM SPSS Statistics 23.0, Armonk, NY.

Results

Between April 1, 2015, and October 31, 2019, 3,871 women delivered at the Division of Obstetrics and Gynecology, Department of Maternal, Neonatal and Infant Health, ASL Biella, Biella, Italy. Of the total deliveries, 1,089 (28.13%) were cesarean sections, 140 (3.62%) were operative vaginal deliveries, and 2,642 (68.25%) were spontaneous vaginal births. Among women who had a spontaneous vaginal delivery, we identified and included in the exposed group 144 (5.45%) women who delivered in water. Out of the remaining 2,498 (94.55%) women who had a spontaneous vaginal delivery on land, we identified 265 (10.61%) women who would have been eligible for waterbirth. Only three women who entered the pool and labored in water delivered on land and were excluded from the final analysis.

Demographic, obstetric, and labor characteristics of the 144 exposed women (water delivery) and the 265 unexposed women (land delivery) are summarized in ►Table 2. No differences were observed in maternal demographic characteristics between the two groups as well in the obstetric characteristics apart from the rate of women with premature rupture of membranes, which was significantly higher in the land delivery group (26.4 [38/144] vs. 37.7% [100/265]; $p = 0.022$). Among labor characteristics, we observed a higher proportion of induction of labor in the water delivery group (11.1 [16/144] vs. 5.2% [14/265]; $p = 0.032$), whereas a longer II stage of labor (mean difference: −7.42 min; 95% CI: −13.66 to −1.19; $p = 0.02$) and higher rates of labor augmentation (1.4 [2/144] vs. 11.3% [30/265]; $p < 0.001$) were observed in the land delivery group. Labor analgesia was used in a statistically significantly higher proportion of mothers in the land delivery group (1.4 [2/144] vs. 24.9% [66/265]; $p < 0.001$). This was true both for epidural (0 vs. 10.2%) and Entonox analgesia (1.4 vs. 14.7%).

Maternal outcomes are summarized in ►Table 3. Water delivery was associated with a significantly lower use of episiotomy (0 [0/144] vs. 7.5% [20/265]; $p < 0.001$) and lower blood loss (mean difference: 90.67 mL; 95% CI: 162.95–18.38; $p = 0.014$). We did not observe any significant difference in the distribution of hospital stay length between the two groups; however, a significantly higher proportion of women who experienced water delivery had puerperal fever (5.6 [8/144] vs. 1.1% [3/265]; $p = 0.02$; OR: 5.12; 95% CI: 1.45–23.65; $p = 0.017$), although women who experienced land delivery reported a higher white blood cell count after

Table 2 Demographic, obstetric, and labor characteristics of pregnant women included in the study according to the mode of delivery

	Water delivery ($n=144$)	Land delivery ($n=265$)	p-Value
Demographic characteristics			
Age, y, mean (SD)	31.10 (5.11)	30.89 (5.88)	0.702
BMI, kg/m^2, mean (SD)	22.04 (2.60)	22.60 (4.12)	0.102
Weight gain, kg, mean (SD)	+12.11 (4.01)	+12.12 (4.56)	0.990
Nulliparity, *n* (%)	76 (52.8%)	151 (57%)	0.466
Smoking, *n* (%)	16 (11.1%)	17 (6.4%)	0.127
Foreign origin, *n* (%)	12 (8.3%)	34 (13.2%)	0.250
Obstetric characteristics			
Gestational age at delivery, wk, median (IQR)	40 (39–40)	39 (39–40)	0.111
GDM, *n* (%)	8 (5.6%)	23 (8.7%)	0.329
PROM, *n* (%)	38 (26.4%)	100 (37.7%)	**0.022**
Oligohydramnios, *n* (%)	9 (6.3%)	8 (3%)	0.127
Admission Hb, g/dL, mean (SD)	12.16 (1.17)	12.16 (1.28)	1.000
Admission WBC, 10^9/dL, mean (SD)	11.48 (3.49)	11.80 (3.59)	0.399
Labor characteristics			
Labor induction, *n* (%)	16 (11.1%)	14 (5.2%)	**0.032**
Rectovaginal colonization with GBS, *n* (%)	9 (6.3%)	30 (11.3%)	0.08
Stage I length (min), mean (SD)	167.28 (91.41)	162.56 (94.93)	0.625
Stage II length (min), mean (SD)	37.27 (26.90)	44.70 (36.31)	**0.020**
Labor augmentation, *n* (%)	2 (1.4%)	30 (11.3%)	$<$**0.001**
Fever in labor, *n* (%)	3 (2.1%)	5 (1.89%)	0.523
Labor analgesia, *n* (%)	2 (1.4%)	66 (24.9%)	
Epidural, *n* (%)	0 (0%)	27 (10.2%)	$<$**0.001**
Entonox, *n* (%)	2 (1.4%)	39 (14.7%)	$<$**0.001**

Abbreviations: BMI, body max index; GBS, Group B Streptococcus; GDM, gestational diabetes mellitus; Hb, hemoglobin; IQR, interquartile range; PROM, premature rupture of membranes; SD, standard deviation; WBC, white blood cell count.

Table 3 Maternal outcomes of women included in the study according to the mode of delivery

	Water delivery ($n=144$)	Land delivery ($n=265$)	p-Value
Delivery outcomes			
Shoulder dystocia, *n* (%)	2 (1.4%)	1 (0.4%)	0.555
Perineal tear $>$ II grade, *n* (%)	0 (0%)	1 (0.4%)	1.000
Episiotomy, *n* (%)	0 (0%)	20 (7.5%)	$<$**0.001**
Trachelorrhaphy, *n* (%)	1 (0.7%)	3 (1.1%)	1.000
Manual placental delivery, *n* (%)	1 (0.7%)	7 (2.6%)	0.270
Curettage, *n* (%)	2 (1.4%)	10 (3.8%)	0.229
Blood loss, mL, mean (SD)	240 (193)	331 (415)	**0.014**
Major postpartum hemorrhage ($\geq$1,000 mL), *n* (%)	2 (1.4%)	12 (4.5%)	0.152
Puerperium outcomes			
Postpartum Hb, g/dL, mean (SD)	9.92 (1.64)	9.24 (1.46)	0.071
Postpartum WBC, 10^9/dL, mean (SD)	12.21 (4.25)	14.32 (4.74)	**0.043**
Puerperal fever, *n* (%)	8 (5.6%)	3 (1.1%)	**0.012**
Length of hospital stay, median (IQR)	3 (3–4)	3 (3–4)	0.428

Abbreviations: Hb, hemoglobin; IQR, interquartile range; SD, standard deviation; WBC, white blood cell count.

Table 4 Neonatal outcomes of the study population according to the mode of delivery

Neonatal outcomes	Water delivery ($n = 144$)	Land delivery ($n = 265$)	p-Value
Male, n (%)	77 (53.5%)	135 (50.9%)	0.679
Weight, g, mean (SD)	3272 (397)	3240 (402)	0.433
Arterial pH, mean (SD)	7.29 (0.12)	7.30 (0.08)	0.787
Arterial BE, mean (SD)	−3.84 (3.98)	−5.10 (2.94)	0.215
Breastfeeding, n (%)	133 (93.7%)	238 (90.2%)	0.269
5′ Apgar < 7, n (%)	1 (0.7%)	2 (0.7%)	1.000
Positive CRP (>5 mg/L), n (%)	6 (4.2%)	4 (1.5%)	0.176
Short umbilical cord (≤45 cm), n (%)	0 (0%)	1 (0.4%)	1.000
Cord avulsion, n (%)	4 (2.8%)	0 (0%)	**0.015**
Neonatal death, n (%)	1 (0.7%)	0 (0%)	0.352
Neonatal ward observation, n (%)	31 (21.5%)	114 (43.0%)	<**0.001**
Neonatal transfer to NICU, n (%)	0 (0%)	1 (0.37%)	0.649

Abbreviations: BE, base excess; CRP, C-reactive protein; IQR, interquartile range; NICU, neonatal intensive care unit; SD, standard deviation.

delivery (mean difference: -2.11×10^9/dL; 95% CI: −4.16 to −0.66; $p = 0.043$).

Neonatal outcomes are reported in ►**Table 4**. No differences were observed in the rate of 5′ Apgar score < 7 between the two groups. Neonates born from mothers who delivered in water had a significantly lower risk of being admitted to the neonatal ward for observation than those delivered on land (21.5 [31/144] vs. 43.0% [114/265], OR: 0.38; 95% CI: 0.24–0.59; $p < 0.001$). Four cases of cord avulsion were observed in the group of women who delivered in water versus no cases reported in the land delivery group (2.8 [4/144] vs. 0% [0/265]; $p = 0.015$). Neonates delivered in water had a significantly higher risk of cord avulsion than those born on land (OR: 17.01; 95% CI: 1.79–2.258; $p = 0.01$; estimated with Firth's correction).

After applying the IPTW method to address possible selection biases related to demographic, obstetrics, and labor characteristics, standardized differences of covariates in the IPTW-adjusted cohort were less than the 0.20 threshold of desirability for all the characteristics (►**Supplementary Table S1** and ►**Supplementary Fig. S1**, available in the online version). In the IPTW-adjusted analysis, water delivery versus land delivery was significantly associated with a higher risk of fever in puerperium (OR: 4.98; 95% CI: 1.86–17.02; $p = 0.004$), of cord avulsion (OR: 20.73; 95% CI: 2.63–2.674; $p = 0.001$; estimated with Firth's correction), and of positive C-reactive protein (CRP > 5 mg/L) in the newborn (OR: 2.59; 95% CI: 1.05–7.24; $p = 0.039$). Delivering in water versus on land was also associated with lower maternal blood loss (mean difference: 110.40 mL; 95% CI: 191.01–29.78; $p = 0.007$) and a lower risk of major (≥ 1,000 mL) postpartum hemorrhage (OR: 0.23; 95% CI: 0.08–0.56; $p < 0.001$), a lower risk of manual placenta delivery (OR: 0.18; 95% CI: 0.03–0.67; $p = 0.008$) and curettage (OR: 0.24; 95% CI: 0.08–0.60; $p = 0.002$), a lower use of episiotomy (OR: 0.02; 95% CI: 0–0.12; $p < 0.001$), and a lower risk of neonatal admission to the neonatal ward for observation (OR: 0.35; 95% CI: 0.25–0.48; $p < 0.001$).

Discussion

Main Findings

Given the limited evidence about the risk and benefits of waterbirth,[7] we decided to focus on maternal and neonatal outcomes associated with immersion in water at the time of delivery. The results of our study showed that water delivery was associated with a higher risk of developing fever in puerperium for the mother and with a higher risk of cord avulsion and positive CRP for the newborn. Conversely, water delivery was associated with a lower maternal blood loss and risk of major postpartum hemorrhage, lower risk of manual placenta delivery and uterine curettage, lower use of episiotomy, and lower risk of neonatal ward admission for observation after delivery.

Interpretation

Regarding maternal outcomes, after IPTW, we observed that waterbirth was associated with a higher odd of puerperal fever. Similar findings were reported by Bovbjerg et al, who performed a large registry-based study on 17,530 waterbirths using propensity scores methods to adjust for confounders. They found that water delivery was associated with a higher risk of maternal uterine infection in the first 6 weeks after delivery (adjusted OR: 1.25; 95% CI: 1.05–1.48).[13] Although a lack of homogeneity in the definition of postpartum maternal infective complications is present in the literature,[15,27,34] both our results and Bovbjerg's results suggest a possible increased risk of maternal infective complications after a waterbirth. In line with previous studies,[10,13,16] we observed that women who delivered in water had a significantly lower amount of blood loss than those who delivered on land, and this difference may be clinically relevant given that water delivery was also associated with a lower risk of major postpartum hemorrhage, manual placental delivery, and uterine curettage after IPTW adjustment.[35] However, observed differences in maternal outcomes between water and land delivery did not reflect in differences in hospital stay length between the two groups, as previously reported.[13] We also acknowledge that, despite women were helped to immediately exit the pool after waterbirth, blood loss quantification after water delivery could have been less accurate with potential underestimation of blood loss in this group. This could have contributed to the observed difference between water and land delivery.

Regarding neonatal outcomes, after IPTW, we found that waterbirth was associated with a significantly lower odd of neonatal ward admission for observation. Of note, the present study was conducted in a second-level center where a NICU was not available and where neonates presenting with specific criteria of concern after birth (e.g., respiratory distress, neonatal jaundice, neonatal hypoglycemia), but not eligible for NICU admission, were admitted to the neonatal ward for observation. Our findings are consistent with those previously reported by other authors who showed that water delivery was not associated with an increased risk of neonatal NICU or nursery admission.[8,13,14,17,27] Given that our results showed that water delivery was associated with a higher risk of positive CPR in neonates, the reasons for differences in neonatal ward admission between the two groups should be attributed to other factors.

In the present study we also observed four cases of neonatal cord avulsion in the water delivery group, whereas none of such events was observed after land delivery. After IPTW adjustment for possible confounders, waterbirth was significantly associated with a higher odd of neonatal cord avulsion. Several lines of evidence show that cord rupture after delivery is more frequently observed in newborns delivered in water than in those delivered on land.[13,14,24–29,36–38] Various mechanisms have been proposed to explain this association. Some authors suggested the difficult handling and excessive traction of the umbilical cord after a water delivery as possible reasons.[36] However, no traumatic events were reported in the four cases described in our study, and the cord length was normal in all cases but one that belonged to the land delivery group. We here propose that another mechanism may be implicated in cord avulsion associated with water delivery and that it could be due to the different temperature and osmotic pressure surrounding the cord when the delivery occurs in warm water rather than on land. The umbilical cord delivered in water at 37°C may not undergo the low-temperature-induced vasoconstriction that causes a physiological occlusion of the umbilical vessels[39]; this may negatively affect the resistance of the umbilical cord, thus favoring the cord avulsion.[40]

Cord rupture represents a serious event, which can lead to neonatal NICU admission and blood transfusion.[24,28,41] In the present study we observed one case of neonatal death due to hemorrhagic shock following cord rupture, suggesting that cord avulsion can potentially be associated with a dismal prognosis. Of note, although cases of neonatal death have been previously described after water delivery,[8,17,41] none was associated with cord avulsion.[41] Our observation stresses that fact that if water delivery is allowed, a trained staff must be present and aware that cord avulsion is possible event and that, once diagnosed, the management should prioritize the risk of severe neonatal hemorrhage. An immediate cord clamping and close neonatal surveillance for abnormal vital signs while waiting for a neonatologist is essential.

Strengths and Limitations

The main limitation of our study is its retrospective observational design and the relatively small number of patients included compared with previously published retrospective studies. RCTs are the gold standard for studying the efficacy of an intervention. However, RCTs might be not able to detect rare events if powered for more frequent outcomes, and new large RCTs are unlikely to begin soon.[13,14] Therefore, observational studies represent an important source of evidence. In this regard, our investigation is strengthened by the inclusion of all consecutive women who delivered in water during the study period, by the use of standardized waterbirth protocol and by the inclusion of all consecutive women who delivered on land who were eligible for water immersion. Further strengths are that data were prospectively collected and medical records revised for data extraction by trained medical staff, which used clear and reproducible definitions. Finally, we clearly defined as "exposure" the water versus land delivery event and as investigated outcomes the outcomes happened after the exposure. The IPTW method was applied to adjust for factors associated with the probability of being exposed or not exposed. The IPTW obtained standardized differences of covariates in the IPTW-adjusted cohort lower than the 0.20 threshold of desirability, allowing addressing for possible selection biases related to characteristics that may act as confounders.

Conclusion

This retrospective study showed that water delivery is associated with a decreased risk of neonatal admission to the neonatal ward for observation after delivery, but with an increased risk of neonatal cord avulsion and positive CRP. We also showed that women who delivered in water had a lower risk of major postpartum hemorrhage, manual placental delivery, or curettage, but a higher risk of fever in the puerperium. The present study focused on the risks and benefits associated with water delivery showing that differences are present between the two delivery modes both for the mothers and the neonates. Among those differences, the risk of cord avulsion is a severe and potentially fatal event associated with water delivery. The possibility of this complication must be acknowledged as well as the importance that a trained and experienced staff is present when water delivery is the delivery mode of choice.

Ethical Approval

All procedures and medical research were conducted in compliance with the ethical principles stated in the Declaration of Helsinki 1975 (revised in 2008). The Institutional Review Board and the Ethical Committee of the ASL Biella/University of East Piedmont approved the study in April 2019 (protocol number: 440/CA; study number: IRB NUMBERCE40/19). All women provided written informed consent for study participation, data collection, and analysis for research purposes.

Authors' Contributions

Conceptualization: S.U., P.M., M.B., M.A.M., S.G.; methodology: S.G., S.U., M.B., I.P., M.A.M.; validation: S.U., P.M., M. P.F., S.G.; formal analysis: S.G., M.B.; resources: S.U., P.M., F. M., T.L.C., C.V.; writing draft: S.U., S.G., M.B.; writing-review and editing: S.U., S.G., M.B., I.P., P.C.Z., G.L., M.A. M., G.B.; supervision: S.U., S.G.

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Conflict of Interest

None declared.

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