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Prophylactic Placement of Internal Iliac Balloons in Patients with Abnormal Placental Implantation: Maternal and Foetal Outcomes

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Abstract
Purpose To report on outcomes following the use of prophylactic internal iliac artery occlusion balloons in patients with abnormal placental implantation.
Methods A retrospective analysis was undertaken of patients with abnormal placental implantation who underwent prophylactic iliac balloon placement prior to delivery in a University Maternity Hospital. Various clinical and technical factors were analysed, including technical success of balloon placement, blood loss and number of blood units transfused, duration of surgery, length of stay, hysterectomy rates, complications related to the balloon insertion, foetal pH and infant Apgar scores.
Results Twenty-two patients with placenta accreta or a variant thereof underwent caesarean section after first undergoing prophylactic placement of bilateral internal artery balloons. Average follow-up duration was 2.08 years. The average gestational age was 37 weeks 6 days, and the mean gravidity was 2.8. The mean number of previous caesarean sections was 2.4, while the mean maternal age was 35 years. The mean intraoperative blood loss was 1.4 L, and the mean number of blood units transfused was 2. Mean duration of surgery was 90 min, mean total length of hospital stay 7.5 days, while the mean duration of ICU/HDU stay was 1.2 days. The balloons were inflated in 60% of cases and two patients (2/22–9%) underwent subsequent hysterectomy. There were no major maternal complications due to the procedure.
Conclusion Prophylactic placement of arterial balloons prior to caesarean section in patients with placenta accreta is well tolerated and leads to satisfactory maternal and foetal outcomes with minimal complications.

Keywords Placenta praevia · Placenta accreta · Placenta percreta · Abnormal placentation · Caesarean section · Interventional radiology · Uterine artery

Introduction

Abnormal implantation of the placenta in the uterus includes placenta praevia (PP), which occurs when the placenta is wholly or partially implanted in the lower uterine segment. Pathologically abnormal implantation of the placenta into the myometrium of the uterus is generally termed 'placenta accreta' (PA), and is further subdivided into placenta accreta (superficial invasion), percreta (deep invasion) and increta (complete invasion of the myometrium with possible invasion of adjacent structures) depending on the depth of invasion [1]. In this article, the general term placenta accreta (PA) will refer to all three grades of abnormal myometrial invasion unless otherwise specified.

The most serious clinical consequence of PP and PA is massive obstetric haemorrhage [2]. In our unit, we have used prophylactic insertion of internal iliac artery balloons

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to manage these cases, which were inflated as needed in order to decrease peri-operative blood loss. We sought to describe the endovascular technique used in our unit, as well as to retrospectively assess both maternal and foetal outcomes from this procedure.

Methods

Following approval by our ethics committee, the records of women who underwent prophylactic biliateral internal iliac artery (IIA) balloons placed before elective caesarean section (CS) were retrospectively assessed. Subjects were identified through the radiology information system (RIS). Patients were further subdivided according to the postoperative pathological classification into those with placenta praevia, accreta, increta and percreta.

In our institution, any mothers who were prenatally diagnosed with either PP or PA have been managed in a multdisciplinary fashion, with involvement of the obstetricians, anaesthetists, interventional radiologists, midwives, neonatologists and intensivists. Ultrasound was the initial screening tool used in all cases—MRI was used as a problem-solving tool only in unclear cases. These patients were admitted if they had significant vaginal bleeding antenatally and asked to stay near the hospital if possible in their third trimester. As the pregnancy progressed, a staged procedure involving interventional radiology and obstetrics was planned. If not already given, antenatal steroids were administered to the patient before the planned delivery date.

On the morning of surgery, an obstetrics theatre was held waiting. The patients underwent an epidural anaesthetic, which was performed in the interventional radiology department. Bilateral vascular access was obtained via the common femoral arteries, and a 5-French vascular sheath placed. Both internal iliac arteries were cannulated using a contralateral approach, usually with a 5-French reverse curve catheter (e.g. C2 catheter, Cordis Corporation, Miami, FL, USA) with a 0.035" hydrophilic wire (Glidewire, Terumo, Somerset, NJ, USA) and the catheter advanced to the anterior branch of the hypogastric artery on each side. A low-profile 6–8 mm standard PTA balloon catheter was then placed on each side—the brand varied depending on the operator preference. Measurement of arterial diameter was performed at the time of balloon insertion to ensure correct balloon sizing. Bilaterally, the sheaths were attached to pressure bags containing heparinised saline (to avoid thrombosis of the arteries), and the sheaths were sutured in place, with a transparent dressing placed over them to further ensure stability. Continuous maternal and foetal monitoring (using cardiotocography) was used throughout the procedure.

In terms of the radiation dose, all possible measures were taken to reduce dose to the mother and the foetus. Doses were maintained according to the ALARA principle and beam-on time was kept to an absolute minimum throughout. Flouroscopy pulse rates were kept to a minimum (3/s or less). Last-image hold was used where possible, and spot X-ray images avoided. The X-ray tube was kept as far away from the patient as possible, while the detector was kept as close to the patient's abdomen as possible. Geometric magnification use was avoided and tight collimation used throughout. Flouroscopy cine loops were stored instead of using DSA. The balloon insertion was performed in an angio suite rather than in the delivery theatre with a C-arm as we felt that this allowed for better image-quality with lower doses to mother and foetus.

The patients were then transferred to the delivery suite. An interventional radiologist was present at the bedside throughout the delivery—if significant bleeding was encountered following delivery of the infant, the balloons were inflated on both sides to help the obstetrician to obtain a bloodless field in an attempt to obtain haemostasis and avoid a hysterectomy. If haemorrhage persisted, and if stable, the patients were transferred back to the interventional radiology suite for definitive endovascular control of the bleeding. If too unstable for transfer, a hysterectomy was then performed if deemed necessary. If there were any obstetrician or paediatric concerns during the delivery, a foetal cord pH was obtained—in our unit, these are not routinely acquired in all patients. Following the delivery—assuming no hysterectomy had been required, and bleeding had been controlled—the sheaths were left in situ for approximately 3–4 h with the heparinised saline pressure bags in place (this was in case of delayed obstetric haemorrhage). The patients were transferred to the post-partum high dependency unit (HDU) and both lower limbs observed routinely for signs of vascular complications. If bleeding had not occurred during this time, both sheaths were then individually removed, and manual pressure applied to the groin. The patients were usually then transferred to the ward the following morning and routine post-partum care resumed. Specific attention was given to nursing the patient flat, monitoring sheath insertion sites in the groin and regular assessment of distal lower limb perfusion. The delivered child was assessed at the bedside by a neonatologist and Apgar scores were recorded.

Results

Between January 2008 and December 2013, a total of 22 patients underwent prophylactic balloon placement. The unit delivers 8000 live births on average per year. 13 of the patients had a prenatal diagnosis of placenta praevia, 6

were diagnosed with placenta accreta, 2 with increta and 1 with percreta. The praevia diagnosis was made as per the pre-term ultrasound (as per sonographer/obstetrician report) while the accreta/increta/percreta diagnosis was made on the preoperative ultrasound and confirmed on the postoperative pathological report.

The median maternal age was 37 years (range 19–42), while median previous gravidity was G3P1 (range Gravidity: 0–6 Parity: 0–4). The median number of previous caesarean deliveries was 1.0 (range 0–6) (Table 1). Catheter placement proceeded following multidisciplinary discussion as outlined above and was always performed in within 2 weeks of the estimated term delivery date. Successful balloon positioning was achieved in 100% of cases and there were no episodes of foetal bradycardia during the procedure.

During the caesarean section, the balloons were inflated in 13 of the 22 patients—there were 2 hysterectomies in total. Balloon inflation was performed at the request of the obstetrician and was performed by the interventional radiologist who was present in the delivery suite. The obstetrician reported decreased rates of bleeding following inflation in all cases. Median duration of obstetric surgery was 75 min (range 19–240 min). There were no patients converted from epidural to general anaesthesia. No patient required transfer to the angiography suite for further management—the patients in whom the hysterectomies were performed were deemed too unstable for transfer and this decision was made by the operating obstetrician in conjunction with the anaesthetist.

Median estimated blood loss was 0.85 L (range 0.3–4.0 L) (Table 2). Median number of blood products transfused (including red blood cells, platelets and fresh frozen plasma) was 0.5 (range 0–23). Median drop in haemoglobin concentration after the delivery was 1.4 (range 0–5) g/dL. Median total length of hospital stay from the morning of elective admission was 4.0 days (range 3–31 days), of which a mean of 1.0 days was spent in HDU/ICU (range 1–6 days).

A total of 23 live infants were delivered—there were two sets of twins and one intrauterine death at 24 weeks who nonetheless had to be delivered in the fashion outlined above due to persistent risks from the placenta praevia despite the infant death. Mean infant Apgar scores at 1 and 10 min were 8.9 and 9.6, respectively. There were umbilical cord pH values available in 11 of the cases—median cord pH was 7.27 (range 7.16–7.31). One infant showed signs of respiratory distress syndrome due to meconium aspiration and was admitted to the neonatal ICU for a total of 7 days—two more were admitted to the neonatal ICU (NICU) for 24 h for observation and one was admitted 48 h later for neonatal jaundice. No infants developed intracranial haemorrhage, evidence of hypoxic ischaemic injury or necrotizing enterocolitis. None of the cohort of infants required follow-up neurological imaging (cranial ultrasound or MRI) during the in-patient stay.

In the placenta praevia group ($n = 13$), the balloons were inflated in seven patients and there were no hysterectomies. In the placenta accreta group ($n = 6$), the balloons were inflated in four patients and there was 1 hysterectomy despite balloon inflation. In the placenta increta cohort ($n = 2$), one patient required balloon inflation and ultimately required a hysterectomy. The patient with placenta percreta, meanwhile, required balloon inflation but did not ultimately require a hysterectomy.

There were no early or delayed maternal complications from endovascular balloon placement, nor was there any damage to adjacent pelvic organs during the operation.

Table 1 Patient demographics (median values)

Age (years)	37
Average gestation (weeks + days)	37 + 2
Gravidity	G3P1
Previous C-sections	1

Table 2 Outcomes (median values)

EBL	850 mL
Blood products transfused	0.00
Hb drop after surgery	1.4 g/dL
Duration of surgery	75 min
Hospital stay (total)	4 days
Hospital stay (ICU/HDU)	1 days
Hysterectomies	2/22 (9%)
Apgar score—1 min	8.8
Apgar score—5 min	9.6
Foetal cord pH	7.27
Foetal bradycardia	0/23
Foetal mortality	0/23
Maternality mortality	0/22

Discussion

Major obstetric haemorrhage—defined as blood loss > 2500 mL, transfusion of > 5 units of blood or documented treatment for coagulopathy—has been identified as one of the main contributors to perinatal morbidity and mortality. Emergency hysterectomy has traditionally been often required to control such bleeding. Increasing rates of PP and PA have also been associated with significant

neonatal morbidities, including lower Apgar scores, increased rates of NICU admission and respiratory distress syndrome. The incidence of PA has been increasing steadily with increasing rates of caesarean section and indeed has been seen to double in the last decade [3].

Transcatheter arterial embolisation was first used to manage major obstetric haemorrhage in 1979 [4] and techniques have evolved since, particularly with the increasing development of uterine fibroid embolization and its similar skill set. Interventional radiology embolisation techniques have been increasingly used as an adjunct to surgery in the management of abnormal placentation. Initially, end-embolization of the uterine arteries was used in an effort to decrease haemorrhage and hysterectomy rates. More recently, many centres have adopted a technique of prophylactic placement of low-profile balloon catheters in the internal iliac arteries prior to elective caesarean section. Following delivery of the infant, these balloons are then inflated if necessary to allow the obstetrician to gain control of the haemorrhage. Some retrospective reviews have questioned the advantages of this technique, arguing that it does not result in reduced blood loss when compared with historic controls [5]. There are also case reports of catheter-related complications [6] while others have described cases of decreased umbilical cord pH [7] which they attributed to catheter-induced iliac artery spasm. Published complication rates with this technique vary from centre-to-centre [8–11]. One of the weaknesses in the literature thus far is that foetal outcomes have not been comprehensively assessed, a problem partially addressed in this series as well as other recent publications [12]. While a randomised control trial is unlikely to ever be carried out in this subject, this study adds to the growing body of evidence that this technique—when performed by experienced operators in a high-volume centre—is safe and efficacious in reducing blood loss and hysterectomy rates when compared with historic controls.

Previous papers have documented a significant maternal complication rate of up to 15% due to balloon placement [13–15], but in our group of 22 patients there were no such complications. There are a number of reasons for why this may be: previous authors have described how, after balloon placement, the patient is transferred to the delivery suite and the balloons are inflated by and at the discretion of the obstetrician. In a busy delivery suite, complications such as balloon overinflation and bursting could easily occur, particularly if these balloons are being managed by clinicians who are not familiar with endovascular techniques. In our institution, interventional radiologist presence at the bedside and later during sheath removal in recovery is mandatory and this is a particularly important aspect of our protocol. Furthermore, in some previous reports the balloons are left uninflated and connected to an inflation device via a stopcock—it is our practice to maintain a heparinised saline pressure-bag connection to avoid the risks of catheter thrombosis and ensuing complications.

This paper also specifically looked at foetal complications—or the lack thereof—from the procedure. There have been historic concerns regarding the potential for iliac balloon-induced ischaemic complications affecting either the mother or baby in the time surrounding the delivery. We found no evidence of such ischaemic complications—either biochemical (by means of cord pH analysis) or clinical (in terms of foetal outcome).

It is also worth noting in our cohort the lack of damage to adjacent pelvic organs during the procedure—historically, there has been a relatively high rate of collateral damage during an emergency hysterectomy. However, it is clear that the relatively bloodless field afforded by balloon inflation allows for a more measured approach, making the safe identification of adjacent organs more likely. This is evident as well in the relatively low estimate-blood loss in our cohort of patients—at 0.85 L, this is significantly lower than the average of 3 L which has been reported in the control groups in other recent series [13]. We have consequently demonstrated a much lower usage of transfused blood products.

One other important point is the safety of heparin use in pregnancy—there are no large cohorts in the literature with regard to intra-arterial heparin use, nor are there likely to be, however the use of intravenous unfractioned heparin in pregnant patients with thromboses (e.g. PE, intra-cranial venous thrombosis) is well described and well tolerated, with a large-systematic review documenting the safety of this approach [16].

The main limitation of the study is of course the retrospective nature of the data collected from a single centre. The lack of randomisation is an issue, as the more complex cases may have been selected for balloon placement while the less severe cases may have tended to undergo standard caesarean delivery. We also only looked at clinical outcomes for the delivered baby during the in-hospital period. Other groups have looked at radiation to the foetus [17]—we have not specifically addressed this in this retrospective cohort, as it requires the use of skin-based thermoluminescent detectors (TLDs) which are not used as part of the standard protocol in our institution.

In summary, we have shown the benefit to both patients—mother and child—of a measured and multidisciplinary approach to the peripartum management of patients with abnormal placentation. This paper suggests that, if used where possible and where there is good experience with the technique, the use of embolization makes an organ- and fertility-sparing delivery much more likely, and the prophylactic placement of these iliac catheters allows rapid control of bleeding where needed.

Rates of placenta praevia and accrete are rising for a myriad of reasons and are predicted to rise further. We believe that our use of this technique has led to improved outcomes for both mother and infant when compared with both previously published outcomes and our own institutional experience. As has been pointed out by other authors [18], it also enforces the benefits of onsite interventional radiologists in our large maternity hospitals. Although more research in this topic is undoubtedly needed, it is our hope that this study will strengthen the evidence in favour of the use of this technique, standing as it is a valuable tool in the our armamentarium for use against this often life-threatening condition.

Conclusion

Prophylactic placement of internal iliac balloons in patients with abnormal placental implantation undergoing delivery is an effective procedure that results in lower than previously encountered blood loss. It is safe for both mother and baby and, in our experience, results in decreased rates of hysterectomy when compared with historic controls.

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Author's Contribution DT, RG, LS, JB, O'OC, PN: conception and planning, collecting and analysing data, writing up of the work.

Compliance with Ethical Standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The procedures of the study received ethics approval from the local institutional ethics committee (Cork University Maternity Hospital, confirmation received 10/03/2013 Ref: CUMH).

Informed Consent Informed consent was obtained from all individual participants included in the study.

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