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Original Article

# Intraoperative aortic balloon occlusion in patients with placenta previa and/or placenta accreta: a retrospective study

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ABSTRACT

*Objective:* To introduce the primary experience of using aortic balloon catheters during cesarean section for placenta previa and/or placenta accreta.
*Materials and Methods:* From January 2013 to May 2015, 43 patients who were preoperatively diagnosed with major placenta previa and/or placenta accreta and who underwent prophylactic aortic catheterization before caesarean section (CS) were included in the study. We analyzed the clinical data of the study population. Surgery- and catheterization-related complications were also reported.
*Results:* Major placenta previa or placenta accreta was surgically confirmed in 42 patients, 28 of whom had both conditions. The mean patient age was 32.3 ± 5.5 years, whereas the median gestational age at delivery was 260 (range, 153–280) days. Twenty-nine (67.4%) patients had previously undergone CS, and 13 (30%) patients had undergone emergency surgery for antenatal hemorrhage. The median estimated blood loss during surgery was 500 (range, 100–3,000) mL, and the median duration of occlusion was 20 (range, 5–32) minutes. Hysterectomy was performed in five (11.6%) patients and uterine artery embolization in two (4.6%) patients. Two patients with placenta percreta experienced surgery-related complications, and two patients required hospital readmission. No major catheterization-related complications were observed. Forty-two live births were recorded, and the Apgar score of the infants at 5 minutes was > 7.
*Conclusion:* Intraoperative aortic balloon occlusion is a relatively safe method for treating placenta previa and/or placenta accreta during scheduled and emergency CS and might be helpful to prevent hysterectomy and embolization in women wishing to preserve fertility.


## Introduction

Placenta previa and morbidly adherent placenta (MAP) may cause significant maternal morbidity and mortality from postpartum hemorrhage (PPH), which accounts for ~ 29% of maternal mortality cases [1–3]. MAP includes placenta accreta, increta, and percreta because it penetrates through the decidua basalis into and through the myometrium. For ease of description, the term "accreta" is usually used for all three conditions.

With the rising incidence of cesarean section (CS) due to increasing maternal age, the incidence of placenta previa and its complications, including placenta accreta, is increasing [4–6]. Elective delivery by CS is recommended for major placenta previa [3], and cesarean hysterectomy although leaving the placenta *in situ* is recommended for placenta accreta [3,7]. For women with placenta accreta who wish to preserve fertility, alternative options include manual removal of the placenta with resection of the invaded area and conservative management leaving the placenta *in situ*; the former approach has a possible risk of massive bleeding upon separation of the placenta, although the latter approach may be associated with secondary complications due to the prolonged retention of placental tissue [8–12].

Intraoperative aortic balloon occlusion (IABO) has been shown to effectively reduce intraoperative hemorrhage in major pelvic surgical procedures [13]. Recently, obstetricians have introduced this technique during CS in patients with placenta accreta and placenta previa because it might not only control bleeding during hysterectomy but may also decrease the likelihood of hysterectomy [14,15].

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In this study, we sought to clarify the maternal and fetal outcomes of a group of patients with major placenta previa and/or placenta accreta who underwent IABO and manual removal of the placenta during CS.

## Materials and methods

This retrospective study was conducted from January 2013 to May 2015 and was approved by the ethics committee of the Sichuan Academy of Medical Sciences and Sichuan Provincial People's Hospital, Chengdu.

### *Inclusion and diagnostic criteria*

Patients whose ultrasound or magnetic resonance (MR) imaging findings revealed major placenta previa and/or placenta accreta met the diagnostic criteria. Those patients with clinical risk factors for placenta accreta, a strong desire to preserve fertility, antepartum bleeding < 500 mL and stable vital signs were included in the study.

The diagnostic criterion of major placenta previa was a completely covered cervix on ultrasound and/or MR imaging. Ultrasound findings considered to be consistent with placenta accreta were an irregular retroplacental sonolucent zone, thinning or disruption of the hyperechoic serosa-bladder interface, the presence of focal exophytic masses invading the urinary bladder, abnormal placental lacunae, or hypervascularity of the placenta-myometrium interface and bladder wall [3,16]. MR imaging findings considered to be consistent with placenta accreta were uterine bulging, heterogeneous signal intensity within the placenta, or dark intraplacental bands on T2-weighted imaging [3]. Clinical risk factors for placenta accreta included the presence of placenta previa complicated by a history of at least one prior CS, or having had more than three previous pregnancies.

The postoperative diagnosis of placenta accreta was based on the following: (1) the pathology of either placental bed biopsies or hysterectomy specimens indicating that the placental villi were in direct apposition to the myometrium [17]; and (2) the surgeon's inability to develop a clear cleavage plane between the placenta and the uterus with massive bleeding from implantation [15].

### *Procedure*

All patients who opted for IABO before CS were adequately counseled, and they provided written informed consent for the procedure. Patients with asymptomatic placenta previa or placenta accreta opted for elective surgery after 36 weeks, and patients with prenatal vaginal bleeding or uncontrolled contractions had an emergency CS.

All patients underwent an elective/emergency CS after aortic catheterization by an experienced interventional radiologist. After local anesthesia, the right femoral artery was punctured using the Seldinger technique, and a 12-F sheath (RCF-12.0-38-J, Cook Medical Inc., Bloomington, IN, USA) was inserted. A 10-F occlusion balloon catheter (CODA-10.0-35-100-32, Cook Medical Inc., Bloomington, IN, USA) was inserted with its tip in the aorta but below the level of the renal artery (Figure 1, Position of the aortic balloon catheter). Accurate placement of the balloon and effective vascular occlusion were angiographically confirmed during balloon inflation using a contrast agent. The balloon was then deflated and the volume of the contrast agent required to inflate each balloon (5–8 mL) was recorded in the patient notes. The sheath/balloon catheter system was then fixed to the skin.

The patients were transferred from the interventional radiology (IR) suite to the operating room for CS under general anesthesia. Immediately after delivery and umbilical cord clamping or before the uterine incision, according to the obstetrician's request, the balloons were inflated using a predetermined volume of normal saline. The occlusion duration was recorded for all patients. Manual extraction of the placenta was then attempted. The patients were administered uterotonic agents, such as oxytocin or carboprost trometamol, and hemostatic suturing and/or internal iliac artery (IIA) ligation were performed, if necessary. The indication for hysterectomy was uncontrolled bleeding despite the aforementioned surgical and medical interventions.

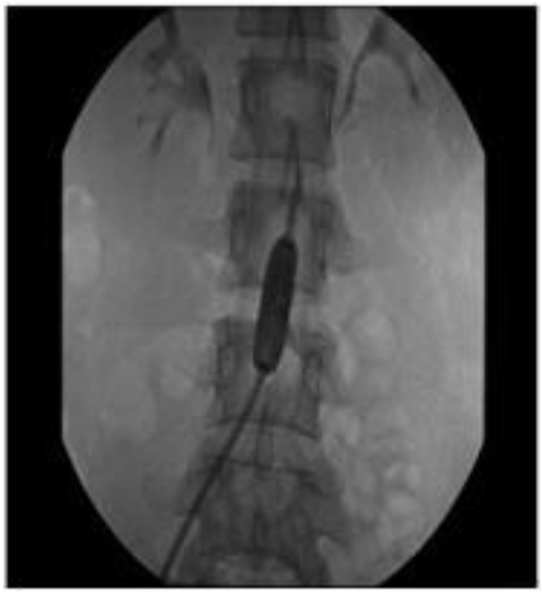

**Figure 1.** Position of the aortic balloon catheter.

The balloons were routinely deflated before closing the peritoneal cavity to confirm hemostasis. For continuous bleeding that was not massive, the patient was transferred to the IR suite for uterine arterial embolization (UAE). The catheters were removed by the radiologist as soon as the patient's vital signs stabilized.

Perinatal outcomes such as estimated blood loss (EBL), duration of surgery, duration of occlusion, transfused blood product units, incidence of hysterectomy and UAE, number of intensive care unit (ICU) and neonatal intensive care unit (NICU) admissions, and Apgar scores at 1 minute and 5 minutes after birth were considered. Estimated blood loss was quantified based on the volume of suction containers, the weight of the surgical pads, and visual estimation of vaginal blood loss. Surgery- and catheterization-related complications were also reported.

### *Statistical analysis*

The Kolmogorov–Smirnov and Shapiro–Wilk tests were used to assess normal data distribution. Data are presented as the mean ± standard deviation or median and range, where appropriate. Continuous variables were analyzed using the Mann–Whitney U-test. Categorical variables were presented in the form of a rate. Data were analyzed using SPSS 19.0 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $p < 0.05$.

## Results

### *Characteristics of the study population*

During the study period, 43 patients who were preoperatively diagnosed with major placenta previa and/or placenta accreta

consented to catheterization before CS. The characteristics of the study population and the outcomes are summarized in Table 1.

The mean age of the study population was 32.3 ± 5.5 years and the median number of gravida/para was 4 (1–8)/1 (0–2). Eight (18.6%) patients were nulliparous and 29 (67.4%) patients underwent CS previously. Antenatal diagnosis of major placenta previa was made in 17 (39.5%) patients. Twenty-four (55.8%) patients were prenatally diagnosed with major placenta previa with placenta accreta. In five of these patients, the diagnosis of placenta accreta was suspected based on the clinical risk factors. Two (4.7%) patients were diagnosed with single placenta accreta (Figure 2, Distribution of the study population by preoperative and postoperative diagnoses).

Thirteen (30%) patients underwent emergency CS because of prenatal vaginal hemorrhage. The amount of blood loss ranged between 100 mL and 500 mL. The median gestational age at delivery was 260 (range, 153–280) days. Midway during the pregnancy, two patients requested termination of pregnancy by CS, and their gestational ages were 154 days and 153 days. Both patients already had one child, and both were excluded when the neonatal outcomes were analyzed.

**Table 1**
Summary of patient characteristics and outcomes.

| | Total ($n$ = 43) | | |
|---|---|---|---|
| | *N* (%) | Mean (± SD) | Median (range) |
| Age (y) | | 32.3 ± 5.5 | |
| Gravida/para | | | 4 (1–8)/1 (0–2) |
| Nulliparous women | 8 (18.6) | | |
| Patients with prior cesarean section | 29 (67.4) | | |
| Gestational age at delivery (d) | | | 260 (153–280) |
| Emergency surgery | 13 (30) | | |
| Duration of occlusion (min) | | | 20 (5–32) |
| Estimated blood loss (mL) | | | 500 (100–3000) |
| Transfusion | 25 (58.1) | | |
| Duration of operation | | | 70 (38–325) |
| Cesarean hysterectomy | 5 (11.6) | | |
| Patients requiring UAE | 2 (4.6) | | |
| Patients transferred to ICU | 4 (9.3) | | |
| Catheter-related complications | 1 (2.3) | | |
| Infant complications | 1 (2.3) | | |

ICU = intensive care unit; SD = standard deviation; UAE = uterine artery embolization.

*Surgical outcomes*

Surgery confirmed single major placenta previa in 13 (30%) patients, placenta previa with accreta in 28 (65%) patients, and single placenta accreta in one (2.3%) patient. One patient was preoperatively diagnosed with single placenta accreta. However, no evidence of placenta accreta was found during surgery. Four patients had placenta percreta, which was confirmed by both surgery and pathological findings.

The balloon catheters of all patients were inflated. The median occlusion duration was 20 (range, 5–32) minutes. Of these, 15 (34.8%) were inflated before the uterine incision, and 28 (65.2%) were inflated after delivery. An obvious decrease in bleeding at the time of balloon inflated was noted in 32 (74.4%) patients. The median estimated blood loss was 500 (range, 100–3000) mL. Twenty-five (58.1%) patients were transfused with 400 (range, 0–2500) mL of blood. The median surgery duration was 70 (range, 38–325) minutes.

Five women underwent hysterectomy immediately after CS because of uncontrolled postpartum hemorrhage, and four of them had placenta percreta. Two patients were transferred to the IR suite

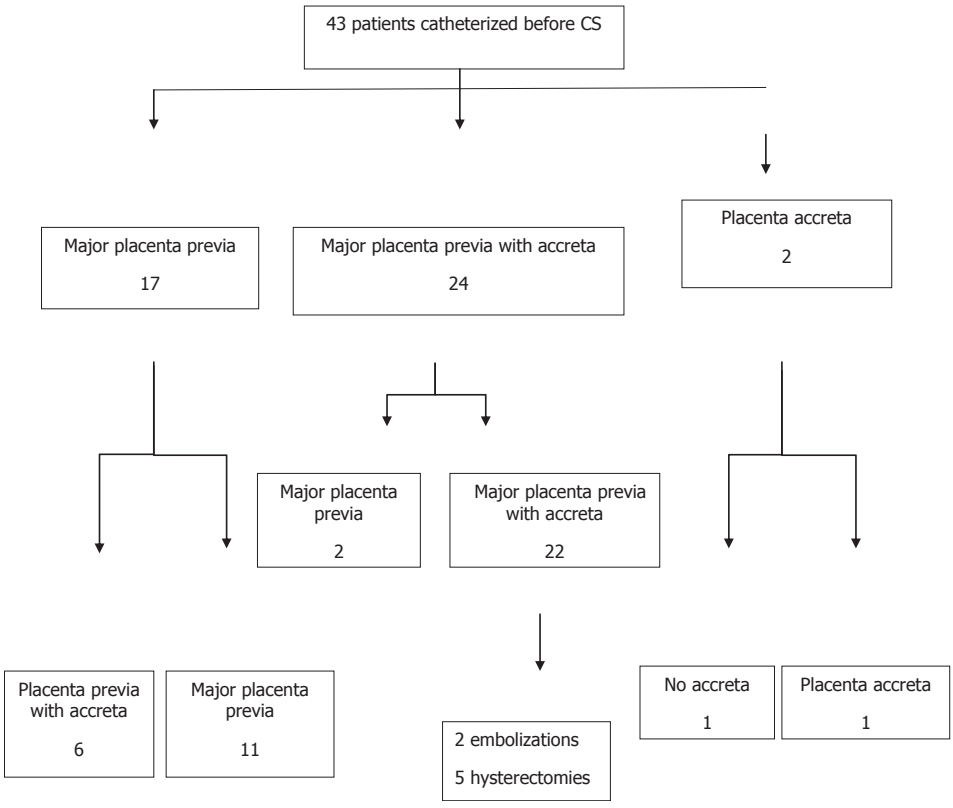


**Figure 2.** Distribution of the study population by preoperative and postoperative diagnoses. CS = cesarean section.

for UAE after CS because of partial placental retention and steady but scant vaginal bleeding. Four (9.3%) patients were transferred to the ICU after CS.

To evaluate the effects of different parameters on the EBL and duration of the operation, the data were analyzed as follows: (1) time of balloon inflation before incision in the uterus versus after delivery; (2) number of previous CS: zero versus one or more; and (3) type of diagnosis: placenta previa versus placenta previa with accreta. The outcomes of the comparisons are listed in Table 2.

### *Complications*

Two patients with placenta percreta experienced surgery-related complications. One patient sustained bladder damage, which was repaired followed by the placement of a ureteral stent immediately after CS by a urological surgeon. The other patient had suspected ureteral impairment, which was managed by the placement of a ureteral stent during surgery. Two patients required hospital readmission: one for late postpartum hemorrhage on the 29$^{th}$ day after CS and the other for a pelvic inflammatory mass on the 12$^{th}$ day after CS. The former patient recovered after medical treatment, whereas the latter underwent surgery during which severe adhesions were observed between the edematous omentum majus and partial intestinal canal creating an inflammatory mass. Partial omentum majus resection and excision of the edematous right fallopian tube of this patient were performed.

No major catheterization-related complications were observed. One patient with placenta accreta had a minor complication, i.e., pain in her right leg, which was caused by an ultrasound-confirmed hematoma along the anterior wall of the right common femoral artery. This patient refused further examination and her condition spontaneously remitted.

### *Neonatal outcomes*

In total, 42 live births were reported in our study, excluding two stillbirths and including a pair of twins. The Apgar score of all newborns immediately after birth was > 7 except for one infant who had severe asphyxia; the Apgar score at 5 minutes after resuscitation was 8, and the infant was transferred to the NICU. Four other newborns were also transferred to the NICU: two of those infants were prematurely delivered at almost 32 weeks, and a pair of twins had suspected respiratory distress syndrome. All the infants were discharged upon recovery.

## Discussion

PPH remains the leading cause of mortality among pregnant women in China. Cesarean hysterectomy is the definitive treatment for life-threatening postpartum bleeding caused by placenta previa and placenta accreta. Increasing expectations regarding quality of life have shifted the management approach for this condition, with attempts being made to conserve the uterus, not only to preserve fertility.

Previous studies have evaluated endovascular balloon occlusion of the pelvic arteries with or without embolization to reduce intraoperative blood loss during cesarean hysterectomy for placenta accreta [14,18–23]. However, only a few studies have focused on uterine preservation. Table 3 shows the results from recently published studies (case reports excluded) in which endovascular balloon occlusion with or without UAE was performed during CS for major placenta previa and/or placenta accreta with the aim of preserving the uterus and reducing hemorrhage. The most common type of occlusion in these studies was internal iliac artery balloon occlusion, with varying findings reported regarding the EBL amount and hysterectomy rate. Differences in the study design, study populations, and the definitions of placenta accreta may partially account for the differences among the studies.

As shown in Table 3, all the studies that included a control group concluded that the EBL amounts in the endovascular balloon occlusion group were significantly lower than those in the control group [15,24–26], and Panici et al [15] reported that IABO might significantly reduce the incidence of cesarean hysterectomy. According to the data summarized in Table 3, the incidence of a second hysterectomy in patients who received IABO was 6/100 (6%), whereas it was 26/159 (16.4%) in patients with IIA occlusion. Although our data are limited, our study reported a relatively lower EBL volume and a lower incidence of hysterectomy and embolization.

The potential risks of IABO include ischemic change of the lower extremities, aortic rupture, aortic dissection, branch vessel occlusion, reperfusion injury, dislodgement of a plaque with subsequent embolization to a distal vessel and inability to deflate or withdraw the balloon through the sheath [15,18]. In the present study, no significant catheterization-related complications were observed despite the 30% of patients who underwent emergency CS, which was an outcome that was similar to that found in other studies concerning IABO [15,32]. Although some other retrospective studies regarding IIA or uterine artery (UA) occlusion reported an overall catheterization-related complication rate of 7.7–36% [28–31], the complications mainly included leg claudication after recovery, right iliac artery thrombosis, groin hematoma, and catheter displacement. The fact that the same surgical team performed the catheterizations in our study may have contributed to the low rate of catheterization-related complications.

Prophylactic occlusion of the infrarenal aorta may provide a higher degree of pelvic devascularization than occlusion of the internal iliac or uterine artery by simultaneously occluding the collateral circulation, which might be more extensive in the late gestational period. This approach might provide surgeons good control of bleeding during the manual removal of the placenta. Technically, the former is a less difficult procedure than the occlusion of smaller arteries such as the IIA or UA and may be performed rapidly because unilateral catheter insertion is sufficient and the lodging location may be easily identified. These advantages favor the use of IABO in an emergency setting, which consequently would reduce the exposure of the patients and fetus to radiation. Panici et al [15] reported a radiation dose documented by

**Table 2**
Estimated blood loss and duration of operations in different categories.

| | Timing of balloon inflation | | | No. of previous cesarean deliveries | | | Diagnosis | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before incision in uterus | After delivery | *p* | 0 | ≥ 1 | *p* | Placenta previa | Placenta previa with accreta | *p* |
| EBL, mL (range) | 700 (100–3000) | 500 (200–2000) | 0.56 | 325 (1000–2000) | 800 (200–3000) | 0.001 | 350 (100–500) | 750 (200–3000) | 0.001 |
| Operation duration, min (range) | 65 (45–325) | 72.5 (36–165) | 0.9 | 62.5 (36–165) | 75 (48–325) | 0.11 | 60 (38–117) | 80 (45–325) | 0.008 |

EBL = estimated blood loss.

**Table 3**
Summary of primary outcomes following balloon occlusion in the literature.

| Reference | No. of balloon inflations | Type of occlusion | EBL (l) | No. of embolizations | No. of hysterectomies | Emergency surgery | Catheterization-related complications |
|---|---|---|---|---|---|---|---|
| Tan et al 2007 [24] | 11 | IIA (internal iliac artery) | 2.0 | 5 (45.5%) | 4 (36.4%) | Not available | No catheter-related complications |
| Mok et al 2008 [30] | 6 | IIA | 6.5 | 0 | 4 (66.7%) | 2 (33.3%) | 1 left leg claudication after recovery |
| Sivan et al 2010 [27] | 30 | IIA | 2.0 | 23 (76.6%) | 2 (6.6%) | 0 | No major catheterization-related complications |
| Thon et al 2011 [31] | 11 | IIA | 4.6 | 1 (9.1%) | 9 (81.8%) | 5 (45.5%) | 3 minor & 1 related to catheter displacement & prolonged resuscitation |
| Sadashivaiah et al 2011 [28] | 13 | Uterine artery | | 1 (7.7%) | 0 | Not available | 1 groin hematoma |
| Panici et al 2012 [15] | 15 | Abdominal aorta | 0.95 | Not available | 2 (13.3%) | 0 | No catheter-related complications |
| Darwish et al 2014 [25] | 32 | IIA | 1.9 | Not available | 4 (12.5%) | Not available | No catheterization-related complications |
| Teixidor Vinas et al 2014 [29] | 27 | IIA | 1.9 | 8 (29.6%) | 3 (11.1%) | 1 (3.7%) | 2 migrations of the balloon & 1 right iliac artery thrombosis |
| Broekman et al 2015 [26] | 42 | IIA | 0.8 | Not available | 0 | 0 | No catheterization-related complications |
| Duan et al [32] | 42 | Infrarenal abdominal aorta | 0.58 | 100% | 1 (3.1%) | Not available | 1 failed catheterization |
| Present study | 43 | Infrarenal abdominal aorta | 0.5 | 2 (4.6%) | 5 (11.6%) | 13 (30%) | No major catheterization-related complications |

EBL = estimated blood loss; IIA = internal iliac artery.

dosimetry of approximately 0.1 mGy during the infrarenal aortic balloon catheter placement procedure and a fluoroscopy time for all cases of < 5 seconds. By contrast, catheterization of the IIA or UA has been reported to require a mean fluoroscopy time of several minutes [26,29], and a mean radiation dose of 132.4 mGy [29]. In the current study, the aortic balloon catheters were placed by experienced radiologists to minimize fluoroscopy exposure, which ensured that the total dose did not exceed 50 mGy and that the long-term effects on the fetus could be minimized.

In categorical data analysis, placenta previa and placenta previa with placenta accreta significantly differed in the amount of EBL and duration of surgery because of the different pathologic mechanisms of PPH. The fact that patients who had undergone CS previously lost more blood during surgery despite using IABO indicates that greater attention should be focused on these patients. Moreover, the amount of EBL and duration of surgery did not differ with the different balloon inflation times in the present study. The balloon inflation time was decided at the surgeon's discretion. The majority of studies have reported balloon inflation after delivery of the infant [20,23,25], whereas Broekman et al [26] reported balloon inflation before the uterine incision.

A safe limitation of 60 minutes for the continuous aortic occlusion duration has been reported for orthopedic operations [33,34]. Within this limitation, the most significant risk is ischemic damage of the extremities, which is rare. Masamoto et al [14] reported a case in which 80 minutes of continuous occlusion was performed during CS for placenta accreta without any surgery- or catheterization-related complications. This long continuous occlusion period is uncommon during CS. The median duration of occlusion was 20 (range, 5–52) minutes in the present study, whereas it was 32 (range, 25–39) minutes [15] and 22.4 ± 7.2 minutes [32] in other studies. In the present study, the aortic balloons were continuously inflated for no > 40 minutes, after which the inflations were alternated with 10-minutes deflations to prevent ischemia in the extremities. We aimed in this study to introduce the primary experience of using an aortic balloon catheter in patients with placenta previa and/or placenta accreta. Therefore, our study lacked a control group. Another unavoidable limitation was the lack of pathological confirmation of the diagnosis of placenta accreta in all patients because the uterus was preserved in some patients. Moreover, the surgical diagnosis may have been influenced by the experience of the surgeons involved.

Based on the findings reported in this study, IABO is a relatively safe method to treat women with placenta previa and/or placenta accreta in both scheduled and emergency CS, and it might be beneficial to prevent hysterectomy and embolization in women who wish to preserve their fertility.

## Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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