

A Dynamic, Intraoperative-Triggered Strategy for Early Bilateral Uterine Artery Ligation During Cesarean Myomectomy in Pregnancies with Giant Fibroids in High-Risk Locations: A Retrospective Case Series of Ten Patients

Huiying Wang

13683266138@163.com

Beijing Shijitan Hospital

Sirui Wang

Capital Medical University

Tianhao Liu

Beijing Institute of Petrochemical Technology

Jin Zhang

Beijing Shijitan Hospital

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Abstract

Background

Pregnancy complicated by giant uterine fibroids in high-risk locations (retroplacental, cervical, submucosal, or intraligamentary) carries a risk of serious obstetric hemorrhage during cesarean myomectomy (CM). Current practice lacks a standardized intraoperative hemostatic decision strategy; most approaches rely on a static preoperative risk label that cannot fully accommodate the dynamic reality of surgical bleeding.

Methods

We retrospectively analyzed a prospectively implemented institutional protocol at a tertiary referral center in Beijing, China (January 2022–November 2025). Ten consecutive patients with singleton pregnancies and at least one giant fibroid (≥ 8 cm) in a high-risk location were managed under a dynamic dual-decision framework: (1) preoperative magnetic resonance imaging (MRI)-based multidisciplinary team (MDT) risk stratification guided surgical preparedness; and (2) the decision to perform early bilateral uterine artery ligation (BUAL) was made intraoperatively, at the first recognition that bleeding was active and accelerating — before progression to established hemorrhage. The bleeding rate that triggered this clinical judgment was calibrated retrospectively against a 150 mL/min threshold, a recognized criterion for massive hemorrhage. The primary outcome was estimated blood loss (EBL). The STROBE guideline was followed.

Results

Ten patients were included (mean age 36.5 years; mean fibroid diameter 12.8 cm). Three patients (Cases 2, 5, and 6; mean diameter 17.7 cm) met the intraoperative trigger and received early BUAL, yielding a mean EBL of 343 mL (range 200–600 mL). The remaining seven patients were managed without BUAL: four with tailored location-specific techniques at intrapartum cesarean, one with antepartum laparoscopic myomectomy, one with postpartum transvaginal resection, and one with expectant management. The overall mean EBL was 256.5 mL. No patient required blood transfusion.

Conclusions

This preliminary case series describes an intraoperative-triggered strategy for early BUAL during CM in pregnancies with high-risk giant fibroids. The approach is hypothesis-generating rather than definitive evidence of efficacy or safety; larger prospective studies with control groups are required. Within the limits of a small, single-center, retrospective case series without a control group, the strategy was associated with modest blood loss and no transfusion, and may be of particular relevance in settings where blood transfusion is not reliably available.

Background

Uterine fibroids are present in approximately 3–12% of pregnancies. Although most remain asymptomatic, giant fibroids (≥ 8 cm) in high-risk anatomic locations — retroplacental, cervical, submucosal, or intraligamentary — can elevate maternal risk through mechanical obstruction of labor and impairment of postpartum uterine contraction, the physiologic mechanism upon which hemostasis at the placental site and any myomectomy bed depends [1–3, 21].

The decision to perform concurrent cesarean myomectomy (CM) remains contentious. Historically discouraged because of the risk of torrential hemorrhage from the hypervascular gravid uterus, CM is now supported by a growing body of evidence — including recent systematic reviews — suggesting that it can be safe in selected cases [4–6]. However, reported mean estimated blood loss (EBL) varies widely (400 to > 1000 mL), and catastrophic hemorrhage remains a documented complication. Critically, current major guidelines acknowledge CM as an option but offer no specific, actionable intraoperative

hemostatic algorithm [7, 8, 23]. The surgeon facing brisk bleeding during tumor enucleation has no standardized decision rule to guide when to escalate from observation to vascular intervention.

Existing hemostatic adjuncts — temporary uterine artery occlusion, perioperative tranexamic acid, and uterine tourniquets — have been studied primarily in non-gravid myomectomy or as reactive rescue measures [9, 10]. International guidelines on postpartum hemorrhage emphasize prevention and early intervention but do not provide an intraoperative bleeding-triggered protocol specific to CM [25, 26]. Severe postpartum hemorrhage remains a leading contributor to maternal morbidity and mortality, with identifiable risk factors that underscore the need for prevention rather than reaction [22]. What is absent from the literature is a strategy in which the decision to escalate to vascular control is driven by real-time intraoperative bleeding behavior rather than solely by a preoperative risk label.

The clinical stakes of this gap extend beyond operative safety alone. In many low- and middle-income countries (LMICs), an estimated annual shortage of over 100 million units of blood coexists with postpartum hemorrhage as the leading cause of maternal death, with over one-quarter of hemorrhage deaths directly attributed to transfusion unavailability [11, 12]. Cesarean deliveries are routinely performed in facilities without a functional blood bank across sub-Saharan Africa and South Asia [13]. In such environments, a surgical strategy that helps prevent hemorrhage from reaching transfusion-dependent severity is potentially valuable.

Here, we describe a dynamic, intraoperative-triggered protocol developed at our institution. Although the protocol centers on intrapartum CM, we report all ten consecutively managed patients — including those managed antepartum, postpartum, or expectantly — to characterize the full clinical spectrum of giant fibroids in high-risk locations and to illustrate the phase-specific flexibility of the protocol. We present this as a preliminary, hypothesis-generating case series.

Methods

Study design and setting

This was a retrospective analysis of a prospectively implemented institutional protocol at the Department of Obstetrics and Gynecology, Beijing Shijitan Hospital, Capital Medical University, a tertiary referral center in Beijing, China. Data were collected from patients managed between January 1, 2022, and November 30, 2025. The study was approved by the Institutional Ethics Committee of Beijing Shijitan Hospital (Approval No. sjtky11-1x-2022(029)) and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants. This report follows the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement [14]; the completed checklist is provided as Additional File 1.

Participants

Inclusion criteria were: (1) singleton pregnancy; (2) at least one uterine fibroid ≥ 8 cm in maximum diameter on prenatal ultrasound or MRI; (3) fibroid in a high-risk or special location (retroplacental, cervical, submucosal, or intraligamentary); and (4) pregnancy managed under the institutional MDT protocol and delivered at our hospital. Exclusion criteria were: (1) multiple pregnancy; (2) known coagulopathy; (3) placenta previa or suspected placenta accreta spectrum; and (4) declined participation. One patient with a 5-cm cervical fibroid was included by MDT consensus owing to the strategic significance of the cervical location despite its diameter being below the 8-cm threshold.

The dynamic dual-decision protocol (Figure 1)

The protocol comprised three components. The first two were preparatory; the third was the operative decision rule.

1. 1. Preoperative MDT assessment and imaging risk stratification. All patients underwent pelvic MRI reviewed jointly by maternal-fetal medicine, gynecologic surgery, radiology, and anesthesiology specialists. Fibroids were classified as high-

risk (diameter ≥ 12 cm, intramural or retroplacental, MRI evidence of extensive myometrial disruption) or lower-risk (all others). This classification guided surgical preparedness – including whether the surgical team prepared for possible BUAL – but did not mandate BUAL. The final decision was made intraoperatively based on actual bleeding.

2. 2. Phase-specific intervention planning. Management was stratified as antepartum (surgery only for acute complications such as torsion or refractory pain), intrapartum (CM at cesarean, with or without BUAL), or postpartum (delayed resection for symptomatic fibroids).
3. 3. Intraoperative decision rule and terminology. During myomectomy, the surgeon assessed bleeding activity in real time. When bleeding was judged to be active and accelerating – at the earliest point before it progressed to established or refractory hemorrhage – BUAL was performed immediately, before continuing tumor enucleation. We use the term "early" BUAL rather than "prophylactic" BUAL because the intervention was performed after the onset of active bleeding, not before it; "early" describes the timing of escalation (at first recognition of accelerating bleeding) rather than a pre-emptive intervention in a non-bleeding field.

Retrospective calibration of the bleeding threshold. The intraoperative decision was a clinical judgment, not a quantitative measurement. To provide an objective benchmark, we retrospectively calibrated this judgment against the bleeding rate implied by the operative record: in all three cases that received BUAL, the estimated bleeding rate exceeded 150 mL/min – a recognized threshold for massive hemorrhage [15, 16]. At this rate, a term gravida can lose over half of her circulating blood volume within 20 minutes if uncontrolled [19]. This threshold was applied retrospectively and should be validated prospectively with quantitative blood loss systems.

The BUAL technique was standardized as follows: (1) the uterus was exteriorized; (2) the uterine arteries were identified bilaterally at the level of the internal cervical os; (3) a No. 1 Vicryl suture (Ethicon, Somerville, NJ, USA) was passed through an avascular window in the broad ligament, lateral to the uterine vessels and medial to the ureter; (4) the suture incorporated a 1–2 cm segment of the ascending uterine artery together with a bite of adjacent myometrium; (5) adequacy of occlusion was confirmed by cessation of pulsation in the ascending branches; and (6) myomectomy was then completed by serosal incision, pseudocapsule entry, blunt and sharp enucleation, and layered closure with No. 0 Vicryl [27].

For patients whose intraoperative bleeding did not reach this level, BUAL was not performed. Instead, location-specific techniques were used: trans-mucosal myomectomy for submucosal fibroids [17], cervical traction and excision for cervical fibroids, and pedicle ligation for pedunculated subserosal fibroids [8].

Data collection and outcome measures

Data were extracted independently by two reviewers (S.W. and T.L.) from the hospital electronic medical record system and cross-validated. The primary outcome was intraoperative EBL, calculated by the gravimetric method. Secondary outcomes included: severe postpartum hemorrhage (EBL ≥ 1000 mL within 24 h), blood transfusion, uterine rupture, unplanned hysterectomy, puerperal infection (temperature $\geq 38.0^{\circ}\text{C}$ on two or more occasions at least 4 h apart after the first 24 h postpartum; Clavien-Dindo grade $\geq$ III [18]), 5-minute Apgar score, and neonatal intensive care unit admission.

Statistical analysis

Given the descriptive nature of this case series ($n = 10$) and the heterogeneity of management pathways, only descriptive statistics are presented: mean (range) for continuous variables and counts for categorical variables. No inferential statistical testing was performed. Analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). No patient was lost to follow-up during the 6-week postpartum period.

Results

Study population. Ten consecutive patients were included (mean age 36.5 years, range 28–43; mean fibroid diameter 12.8 cm, range 5–30). Fibroid locations were retroplacental ($n = 1$), submucosal ($n = 2$), intramural ($n = 2$), cervical ($n = 1$), pedunculated

subserosal (n = 1), and subserosal (n = 3). Individual data are summarized in Table 1.

Table 1
Patient characteristics, management pathway, intraoperative trigger status, and outcomes.

Case	Age (y)	Fibroid location	Max diameter (cm)	Pathway	Technique	Trigger met	EBL (mL)	Transfusion	Notes
1	32	Cervical	5	Intrapartum, lower-risk	Cervical traction & excision	No	150	No	Uneventful
2	41	Retroplacental	30	Intrapartum, high-risk	Early BUAL	Yes	600	No	Figures 2–3
3	34	Pedunculated subserosal	8	Antepartum	Laparoscopic myomectomy	No	5	No	Term CS
4	28	Submucosal	30	Postpartum	Transvaginal resection	No	450	No	Prolapse 8 wk
5	38	Intramural	12	Intrapartum, high-risk	Early BUAL	Yes	200	No	Uneventful
6	42	Subserosal	11	Intrapartum	Early BUAL	Yes	230	No	Uneventful
7	36	Intramural (posterior)	8	Expectant	Induction of labor	No	50	No	IUFD 32 wk
8	43	Submucosal	8	Intrapartum, lower-risk	Trans-mucosal CM	No	280	No	Uneventful
9	35	Subserosal	8	Intrapartum, lower-risk	Pedicle ligation	No	300	No	Uneventful
10	36	Subserosal	8	Intrapartum, lower-risk	Pedicle ligation	No	300	No	Uneventful
Mean EBL (all cases): 256.5 mL. Mean EBL (early BUAL subgroup, n = 3): 343 mL (range 200–600). Transfusion rate: 0% (0/10).									
Abbreviations: EBL, estimated blood loss; BUAL, bilateral uterine artery ligation; CM, cesarean myomectomy; CS, cesarean section; IUFD, intrauterine fetal demise.									

Management pathways. Of the ten patients, three underwent intrapartum CM with early BUAL (Cases 2, 5, and 6); four underwent intrapartum CM without BUAL using tailored techniques (Cases 1, 8, 9, and 10); one underwent antepartum surgery (Case 3); one underwent postpartum intervention (Case 4); and one received expectant management (Case 7).

Early BUAL subgroup (n = 3). Three patients (Cases 2, 5, and 6; mean fibroid diameter 17.7 cm, range 11–30) were judged intraoperatively to have active, accelerating bleeding and received early BUAL. Mean EBL was 343 mL (range 200–600 mL). None of these patients required blood transfusion. Representative imaging from Case 2 is shown in Figs. 2 and 3.

Non-BUAL subgroup (n = 7). Seven patients were managed without BUAL. Four patients (Cases 1, 8, 9, and 10) underwent intrapartum CM with location-specific techniques (cervical traction, trans-mucosal myomectomy, or pedicle ligation); their mean EBL was 238 mL (range 150–300 mL). One patient (Case 3) underwent antepartum laparoscopic myomectomy at 16 weeks for fibroid torsion (EBL 5 mL), with continuation of pregnancy to term. One patient (Case 4) underwent transvaginal resection 8 weeks postpartum for a prolapsed fibroid (EBL 450 mL). No transfusions were required in this subgroup.

Overall outcomes. Across all ten patients, the overall mean EBL was 256.5 mL (range 5–600 mL), and no patient required blood transfusion. There were no cases of severe postpartum hemorrhage, uterine rupture, unplanned hysterectomy, or puerperal infection.

Neonatal outcomes. Of the ten pregnancies, nine resulted in live births; all nine live-born neonates had 5-minute Apgar scores $\geq$ 9. No neonatal deaths occurred among the live births.

Special circumstance — Case 7. One patient with an 8-cm posterior intramural fibroid experienced spontaneous intrauterine fetal demise at 32 weeks. Labor was induced, and EBL was 50 mL; no myomectomy was performed. Placental pathology was unremarkable, and the cause of fetal demise could not be definitively attributed to the fibroid. This case is reported to fully characterize the outcome spectrum in this population [21].

Discussion

Principal findings. This case series describes a dynamic, intraoperative-triggered protocol for CM in pregnancies with giant high-risk fibroids. The core principle is that the decision to perform early BUAL is governed by the patient's own intraoperative bleeding physiology rather than by a static preoperative label. Across ten consecutive patients, this strategy was associated with a mean EBL of 256.5 mL and no blood transfusions. We emphasize at the outset that, given the small sample, the absence of a control group, and the heterogeneity of management pathways, these findings are descriptive and hypothesis-generating; they do not establish the efficacy or safety of the proposed strategy.

The intraoperative trigger and its retrospective calibration. The operative decision to ligate was a clinical judgment, not a prospective quantitative measurement. Retrospective review showed that this judgment corresponded to a bleeding rate exceeding 150 mL/min — a threshold recognized in massive-hemorrhage guidelines [15] and in obstetric definitions of severe postpartum hemorrhage [16]. This correspondence is reassuring in two respects. First, it suggests the surgeon's intraoperative judgment tracked an objective physiological danger signal rather than subjective conservatism. Second, it provides a quantitative benchmark that future protocols could adopt prospectively. We acknowledge the limitation of retrospective calibration and recommend prospective validation with quantitative blood loss systems.

From static labels to dynamic decision-making. The conventional approach to hemorrhagic risk in CM assigns a preoperative "high-risk" or "low-risk" label that dictates a fixed surgical plan. This paradigm has limitations: a "low-risk" label may be wrong — aberrant vasculature, unrecognized placental invasion, or underestimated fibroid vascularity can produce unexpected torrential bleeding. Conversely, a "high-risk" label may encourage unnecessarily aggressive vascular sacrifice in cases where natural hemostasis would have sufficed. Our protocol separates these functions: preoperative imaging guides preparedness, while the actual decision is made at the operative field. Notably, one of the three BUAL cases (Case 6, a subserosal fibroid) was not classified as high-risk preoperatively, yet developed active bleeding that warranted ligation — illustrating that intraoperative physiology, not the preoperative label, should govern the decision.

A safety net, not a universal practice. We emphasize that this protocol is not advocated for all CM. BUAL is a permanent intervention, and although preliminary evidence suggests it does not measurably impair ovarian reserve at 6 months [20], its long-term effects on subsequent fertility and menstrual function remain incompletely characterized. The trigger-based approach is deliberately conservative: it reserves BUAL for cases in which the alternative — uncontrolled hemorrhage — is demonstrably worse. In routine CM where bleeding remains modest, simpler measures are preferable.

Potential transfusion-sparing relevance. The zero-transfusion observation across this series is interesting but should be interpreted cautiously given the absence of a control group. In many LMICs, blood is not reliably available: an estimated annual global shortfall of over 100 million units coexists with maternal hemorrhage as the leading cause of maternal death, with more than one-quarter of hemorrhage fatalities directly linked to transfusion unavailability [11–13]. Cesarean sections are routinely performed in facilities without functional blood banks across large regions of sub-Saharan Africa and South Asia. For a surgeon in such an environment, a suture-based hemostatic option that requires no specialized equipment is a potentially useful tool; this hypothesis, however, requires prospective evaluation.

Limitations. This study has important constraints. First, the sample size is small ($n = 10$), and only three patients received BUAL, precluding statistical inference. Second, the retrospective design — albeit with a prospectively implemented protocol — carries inherent selection and information bias risks. Third, there was no control group, and favorable outcomes may partly reflect

surgical expertise rather than the protocol itself. Fourth, case heterogeneity across four management pathways limits internal validity. Fifth, long-term outcomes (fertility, menstruation, fibroid recurrence, and uterine scar integrity in subsequent pregnancies) were not assessed [20]. Sixth, the single-center, tertiary-unit design constrains external generalizability. Seventh, the intraoperative bleeding-rate assessment was based on clinical judgment rather than quantitative measurement, and its retrospective calibration against the 150 mL/min threshold requires prospective validation.

Clinical implications and future directions. This preliminary experience provides proof-of-concept for an intraoperative, physiology-driven hemostatic protocol, and should be viewed as hypothesis-generating. Future work should include: (1) prospective multicenter cohort studies with a control arm (CM without BUAL) to quantify any transfusion-sparing or hemorrhage-prevention effect; (2) integration of quantitative blood loss measurement tools to standardize the intraoperative trigger prospectively; (3) long-term reproductive follow-up of patients after BUAL; and (4) feasibility studies in LMIC settings.

Conclusions

This preliminary case series describes an intraoperative-triggered strategy for early BUAL during CM in pregnancies with giant high-risk fibroids. The key principle is that the decision to escalate to vascular control is made at the operating table, guided by the patient's real-time bleeding physiology rather than predetermined by a static preoperative label. Across ten consecutive patients, this approach was associated with modest blood loss and no transfusion, and no severe maternal morbidity.

These findings are hypothesis-generating and do not establish the efficacy or safety of the strategy, given the small sample size, the absence of a control group, and the heterogeneity of management. Prospective multicenter studies with appropriate controls and long-term follow-up are required to validate this framework and to determine its role, if any, in settings where blood transfusion cannot be reliably guaranteed.

Abbreviations

- BUAL
- Bilateral uterine artery ligation
- CM
- Cesarean myomectomy
- EBL
- Estimated blood loss
- LMIC
- Low- and middle-income countries
- MDT
- Multidisciplinary team
- MRI
- Magnetic resonance imaging
- PPH
- Postpartum hemorrhage
- STROBE
- Strengthening the Reporting of Observational Studies in Epidemiology

Declarations

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Ethics Committee of Beijing Shijitan Hospital, Capital Medical University (Approval No. sjtky11-1x-2022(029)). All procedures were performed in accordance with the Declaration of Helsinki. Written informed

consent was obtained from all individual participants.

Consent for publication

Written informed consent for publication of clinical details and identifying images — including the intraoperative photograph shown in Fig. 3 — was obtained from all individual participants whose data are presented. Copies of the signed consent forms are available for review by the Editor of this journal upon request.

Competing interests

The authors declare that they have no competing interests.

Authors' information

HW: Master of Medicine, Department of Obstetrics and Gynecology, Beijing Shijitan Hospital. JZ: Doctor of Medicine, Department of Obstetrics and Gynecology, Beijing Shijitan Hospital.

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Author Contribution

HW performed the surgical procedures, collected the clinical data, and drafted the manuscript. SW contributed to data processing and analysis and drafted the manuscript. TL performed the statistical analysis and data interpretation. JZ performed the surgical procedures, conceived and supervised the study, and was responsible for project administration and funding acquisition. All authors read and approved the final manuscript.

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Data Availability

The datasets generated and/or analysed during the current study are not publicly available because they contain individual patient clinical data, but are available from the corresponding author on reasonable request.

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Figures

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Figure 1

Dynamic dual-decision protocol for cesarean myomectomy in pregnancies with giant high-risk fibroids. The algorithm shows: (1) preoperative MDT assessment with MRI risk stratification, which guides preparedness; (2) phase-specific planning (ante partum/intra partum/post partum); and (3) the intraoperative decision rule — when bleeding during myomectomy is judged to be active and accelerating, early BUAL is performed immediately. If bleeding remains modest, location-specific techniques are used. Abbreviations: MDT, multidisciplinary team; CS, cesarean section; BUAL, bilateral uterine artery ligation.

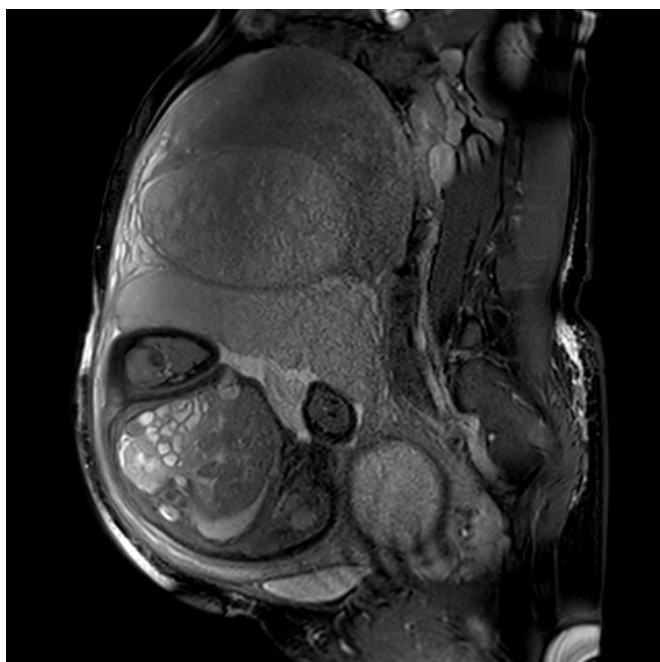


Figure 2

Preoperative sagittal T2-weighted pelvic MRI of a representative high-risk retroplacental fibroid (Case 2). The image shows a giant retroplacental fibroid (F, outlined) posterior to the gravid uterus, with the placenta (P) visible anteriorly; maximum diameter approximately 30 cm. Case 2 was a 41-year-old primigravida.

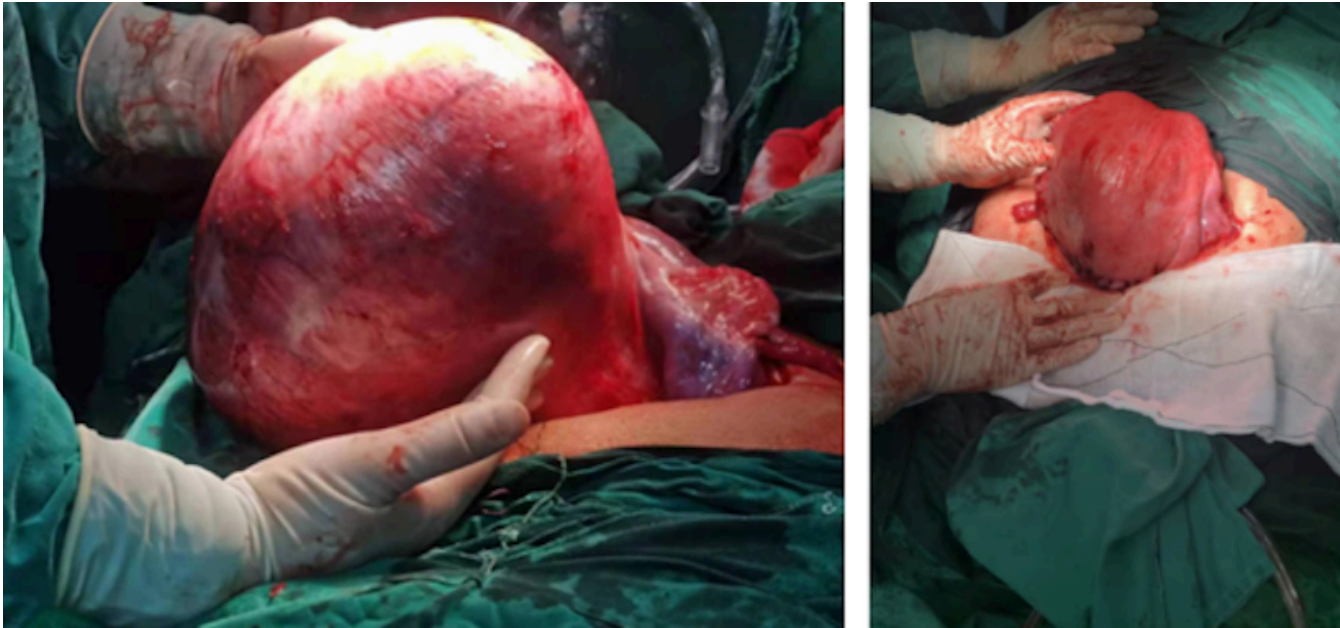


Figure 3

Intraoperative photograph of Case 2 after uterine incision during cesarean section. The exteriorized uterus shows a large posterior fibroid mass. Bleeding during myomectomy reached the intraoperative trigger, and early BUAL was performed (final EBL 600 mL, no transfusion). Written informed consent for publication was obtained.