CASE REPORT

Target-Controlled Infusion (TCI) Propofol in Ventriculoperitoneal (VP) Shunt Surgery during the First Trimester of Pregnancy

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ABSTRACT

Background: The use of target-controlled infusion (TCI) propofol in pregnant patients undergoing ventriculoperitoneal (VP) shunt surgery during the first trimester due to hydrocephalus presents a rare and complex challenge in neuroanesthesia. TCI propofol is favoured for its ability to maintain hemodynamic stability and effectively control intracranial pressure (ICP), both of which are crucial in neuro-obstetric management.

Case: A 23-year-old woman, five weeks pregnant, with a history of communicating hydrocephalus and bilateral VP shunts, presented with severe headache. She underwent emergency VP shunt revision under general anesthesia using TCI propofol (Schnider model, target effect-site concentration 2.5–5 mcg/mL), fentanyl (2 mcg/kg), atracurium (0.5 mg/kg), and lidocaine (1.5 mg/kg). Intraoperative hemodynamics remained stable throughout the two-hour procedure. Postoperatively, her neurological status improved significantly, and no complications were observed.

Discussion: Compared to inhalational agents such as sevoflurane, TCI propofol demonstrates superior control of ICP, maintains cerebral blood flow stability, and facilitates faster postoperative recovery. Fentanyl, atracurium, and lidocaine were selected due to their favourable safety profiles for short-term use in pregnancy. Postoperatively, progesterone was administered to support pregnancy maintenance by reducing uterine contractility and mitigating the risk of miscarriage associated with surgical and anesthetic stress.

Conclusion: TCI propofol is an effective and safe anesthetic strategy for managing VP shunt procedures during the first trimester of pregnancy. A multidisciplinary approach is essential to achieve optimal neurological and obstetric outcomes.

Keywords: hydrocephalus; neuro-obstetrics; pregnancy; TCI propofol; VP shunt

INTRODUCTION

Target-controlled infusion (TCI) propofol is an intravenous anesthetic technique that utilizes a computerized system to achieve a desired drug concentration within the patient's body. The TCI system automatically adjusts the infusion rate based on the targeted plasma concentration, allowing for stable and precise maintenance of anesthetic depth.[1,2] This technique is increasingly used in neuroanesthesia, as propofol has been shown to effectively reduce intracranial pressure (ICP) and better preserve cerebral blood flow autoregulation when compared to inhalational anesthetics.[2,3] TCI propofol provides more precise control of anesthesia, enables smoother induction, maintains hemodynamic stability, and facilitates faster postoperative recovery while reducing the risk of postoperative nausea and vomiting.[2]

Globally, hydrocephalus has an incidence of approximately 3–4 cases per 1,000 live births, with a prevalence of around 85 per 100,000 population.[3] In Indonesia, although comprehensive national data remain limited, one study reported an incidence as high as 10 per 1,000 live births.[4] With advances in the management of hydrocephalus—such as the introduction of silicone catheter systems for shunt placement since the 1960s—many patients now survive into adulthood and reach reproductive age. Although rare, hydrocephalus can present during pregnancy, either as a pre-existing condition or as a new-onset disorder. In such cases, the placement of a VP shunt may be urgently required to reduce elevated ICP and prevent potentially fatal outcomes for both the mother and fetus. As the mainstay treatment for hydrocephalus, VP shunt procedures are widely performed across the globe, with more than 100,000 surgeries estimated annually in developing countries—underscoring the relevance of this intervention even in women of reproductive age.[3]

Neuro-obstetrics, the management of neurosurgical cases in pregnant women, presents unique clinical and technical challenges. Physiological and anatomical changes during pregnancy—such as increased blood volume and cardiac output, reduced pulmonary capacity, and airway edema—can significantly affect anesthetic drug metabolism, complicate airway management, and hinder accurate neurological monitoring.[5] The choice of anesthetic agents and techniques must carefully weigh the risk of teratogenicity, particularly during the first trimester, while also minimizing the risk of fetal hypoxia due to compromised uteroplacental perfusion.

This case report aims to describe the anesthetic and surgical management of a pregnant patient with hydrocephalus undergoing a VP shunt procedure during the first trimester. This case is of particular interest because the application of TCI propofol in neurosurgery during early pregnancy is rarely reported in the literature. It is hoped that this report will provide additional insights for clinical neuroanesthesia practice in pregnant patients and contribute to the growing body of knowledge on the management of complex neuro-obstetric cases.

CASE

A 23-year-old woman, weighing 65 kg, presented with a severe headache accompanied by persistent vomiting for the past 8 hours, which worsened with food intake and did not subside. She reported experiencing similar symptoms four years ago, at which time she was

diagnosed with "fluid in the brain." She underwent right-sided VP shunt placement in 2020, followed by left-sided shunt placement in 2021. The patient also reported a missed menstrual period of approximately one month and a positive home pregnancy test. She had not undergone any antenatal check-ups during the current pregnancy.

The patient was alert and fully oriented. Her vital signs were as follows: blood pressure 120/90 mmHg, heart rate 76 beats/minute, respiratory rate 20 breaths/minute, body temperature 36.2°C, and oxygen saturation 99% on nasal cannula. Pain intensity was rated as 7 out of 10 on the numeric rating scale (NRS). The remainder of the physical examination was within normal limits.

Laboratory findings showed hemoglobin 12.3 g/dL, hematocrit 38.1%, leukocyte count $18.7\times10^3/\mu L$, platelet count $623\times10^3/\mu L$, random blood glucose 80 mg/dL, sodium 137 mEq/L, potassium 4.1 mEq/L, chloride 107 mEq/L, calcium 1.15 mEq/L, prothrombin time 9.9 seconds, and activated partial thromboplastin time (aPTT) 23.8 seconds.

A head CT scan revealed bilateral VP shunt catheters inserted from the right and left parietal regions, with the distal tips located in the lateral ventricles. The caudal tips were not visualized. There was marked dilation of the right and left lateral ventricles, as well as the third and fourth ventricles. Bone window images showed skull defects in the right and left parietal regions. Impression: well-positioned VP shunts, no evidence of kinking, and findings consistent with communicating hydrocephalus accompanied by signs of increased ICP. (Figure 1)

The patient was diagnosed with headache secondary to communicating hydrocephalus in a 5-week pregnant woman, gravida 2, para 1, abortus 0 (G2P1A0). Initial management included intravenous paracetamol 500 mg four times daily and ondansetron 4 mg for symptom control. A preoperative obstetric consultation was conducted, and progesterone was administered at a dose of 3 times daily to support early pregnancy. The patient was scheduled for urgent surgical intervention.

Pre-anesthetic preparation began with obtaining informed consent during the preoperative visit in the emergency department. The patient was thoroughly informed about the planned surgical procedure and the potential risks for both herself and the fetus. She had been appropriately fasted, and an intravenous (IV) line had been established for maintenance with crystalloid fluids.

In the operating room, preparations included setting up the anesthesia machine, airway management equipment, endotracheal tubes (ETT), anesthetic and emergency drugs, end-tidal CO_2 ($EtCO_2$) monitoring, the TCI system, and standard non-invasive monitoring (blood pressure, heart rate, oxygen saturation, and electrocardiogram).

Upon arrival on the operating table, pre-induction monitoring showed blood pressure of 130/65 mmHg, heart rate of 78 bpm, SpO_2 of 99%, and a sinus rhythm of 78 bpm on ECG. The patient was administered fentanyl 130 mcg (2 mcg/kg) for analgesia. Anesthesia was induced using TCI propofol with the Schnider model, targeting an effect-site concentration of 3–5 mcg/mL. Muscle relaxation was achieved with atracurium 35 mg (0.5 mg/kg), and lidocaine 90 mg (1.5 mg/kg) was given to attenuate the airway reflex response.

Endotracheal intubation was performed using a 7.0 mm cuffed ETT, positioned at 20 cm at the angle of the mouth. Mechanical ventilation was initiated in volume-controlled ventilation (VCV) mode with a tidal volume of 500 mL, respiratory rate of 12 breaths per minute, PEEP of 5 cmH_2O, and 50% oxygen. $EtCO_2$ was continuously monitored and maintained within a target range of 25–30 mmHg. Throughout the surgery, anesthesia was maintained with TCI propofol (Schnider model) at a target effect-site concentration of 2.5–5 mcg/mL, with intermittent boluses of atracurium 10 mg administered as needed. (Figure 2)

Intraoperatively, maintenance fluid was administered using 0.9% NaCl crystalloid solution at a total volume of 1500 mL. Output included 250 mL of urine over the 2-hour duration and an estimated blood loss of approximately 30 mL. The surgical procedure lasted for 2 hours.

Throughout the operation, the patient's hemodynamic parameters remained stable, with systolic blood pressure ranging from 102 to 125 mmHg and diastolic pressure between 60 and 80 mmHg. End-tidal CO_2 ($EtCO_2$) levels were maintained between 25 and 30 mmHg, and oxygen saturation (SpO_2) remained consistently stable at 99–100%. Intraoperative neurosurgical assessment revealed a relaxed brain, with a brain relaxation score of 2. A ventriculoperitoneal (VP) shunt was successfully placed on the right side.

Following the completion of surgery, the patient was extubated and transferred to the general recovery ward. Upon arrival in the recovery area, her vital signs were stable with blood pressure at 110/60 mmHg, heart rate of 68 bpm, and oxygen saturation of 99% with oxygen delivered via nasal cannula at 2 L/min. Postoperative analgesia was managed with intravenous paracetamol 500 mg four times daily. Pain was adequately controlled, with a NRS score of 3/10.

On postoperative day one, the patient was fully conscious, calm, and hemodynamically stable with blood pressure of 115/60 mmHg, heart rate of 80 bpm, and oxygen saturation of 99%. An obstetric consultation was conducted to evaluate fetal well-being following surgery. The gestational age was confirmed to be five weeks, and the fetus was assessed to be in good condition. The obstetrician recommended continuing oral progesterone therapy at a dose of three times daily for an additional seven days to support pregnancy maintenance. (Figure 3)

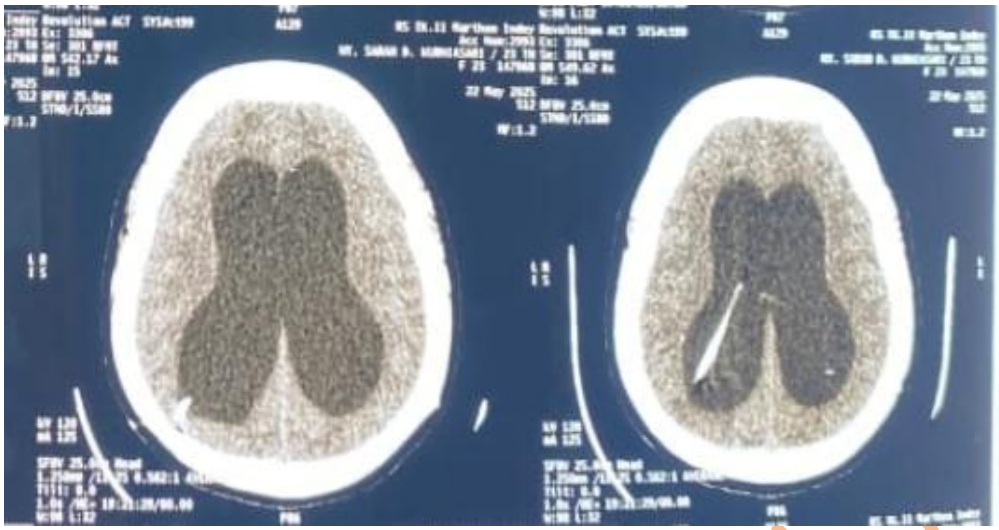

Figure 1: Preoperative CT scan

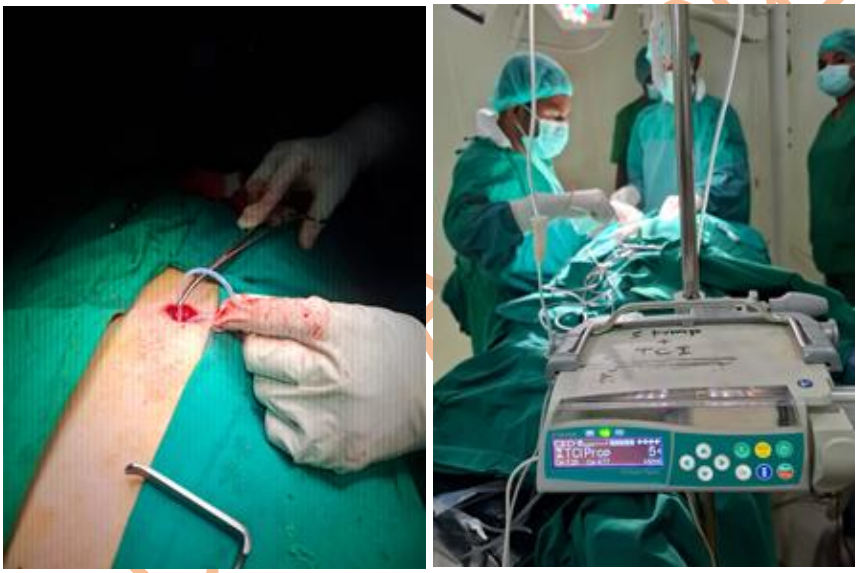

Figure 2: Intraoperative view

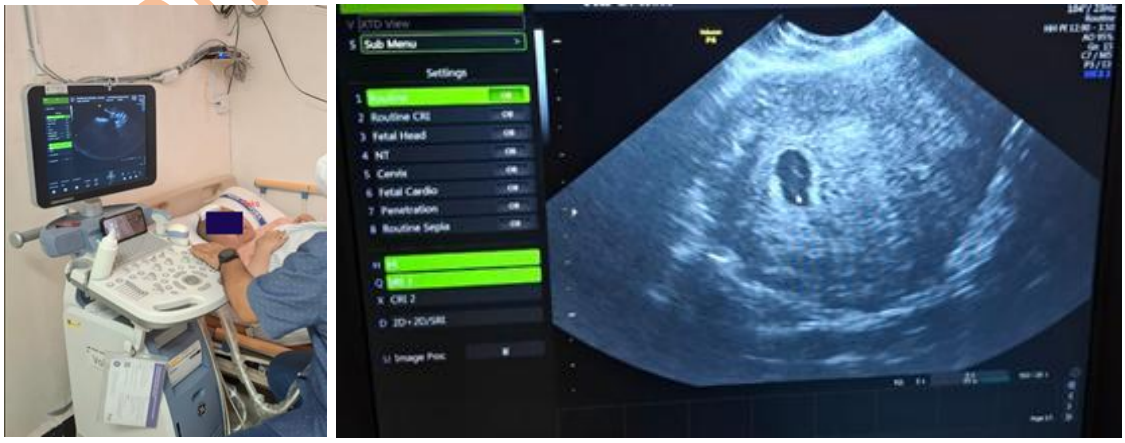

Figure 3: Fetal assessment via ultrasound by an obstetric specialist

DISCUSSION

In this case report, the anesthetic technique employed was TCI using propofol, selected for its ability to maintain consistent and accurate plasma drug concentrations through dynamic dose adjustments based on the patient's individual needs (using the Schnider model).[6] Compared to inhalational anesthetics such as sevoflurane, propofol offers notable advantages, including a greater capacity to reduce ICP, enhance cerebral blood flow, and create optimal surgical conditions for neurosurgical procedures.[7,8] Furthermore, propofol has been shown to effectively reduce the risk of postoperative nausea and vomiting, thereby promoting faster recovery and improving overall patient comfort.[7,9]

In pregnant patients, propofol is considered beneficial due to its short duration of action and the lack of evidence indicating harmful effects on the fetus when used for brief periods.[8,10] Although propofol is known to cross the placenta, clinical doses have not been associated with significant adverse fetal outcomes.[10] The use of TCI allows for precise and lower total dosing of propofol, which is particularly advantageous in pregnancy, where physiological changes alter drug distribution and metabolism. This method enables safer titration tailored to maternal physiology.[6,11]

Conversely, inhalational anesthesia with sevoflurane tends to increase ICP due to its cerebral vasodilatory effects.[8,12] While sevoflurane does offer some neuroprotective benefits—such as anti-apoptotic mechanisms—propofol remains superior in maintaining stable cerebral autoregulation.[7,8,12]

In addition to propofol, other adjunctive medications were utilized in this case, each with a specific role. Fentanyl at a dose of 2 µg/kg was administered to provide analgesia and prevent hypertensive responses and discomfort during intubation. It is considered safe for the fetus at this dosage, as short-term exposure does not result in teratogenic effects.[13,14] Atracurium at 0.5 mg/kg was used to facilitate neuromuscular relaxation during intubation. This agent is regarded as safe in pregnancy due to its minimal placental transfer.[13,15] Intravenous lidocaine at a dose of 1.5 mg/kg was employed to attenuate the cough reflex and intubation-induced nociceptive stimuli, thereby contributing to ICP stability. At low clinical doses, lidocaine is also considered safe for use in pregnancy.[13,16]

A key challenge in this case involved managing the physiological changes that occur during anesthesia in the first trimester of pregnancy. Increases in blood volume, reductions in systemic vascular resistance, and alterations in respiratory function all require vigilant monitoring to ensure adequate cerebral and uteroplacental perfusion. The use of TCI propofol allowed for precise dose titration, enabling the anesthesiologist to maintain hemodynamic stability and thereby reduce the risk of neurological and cardiovascular complications during surgery.[7,11,17]

Neuro-obstetric anesthesia presents several major challenges, including appropriate timing of surgical intervention, adaptation to the maternal physiological changes, and maintenance of maternal oxygenation and blood pressure to safeguard fetal perfusion.[13,17] In this case, urgent surgical intervention was necessary due to elevated ICP, which posed a potentially fatal risk to both the mother and fetus. Although intensive fetal monitoring is not typically required at 5 weeks of gestation, ensuring optimal maternal status remains critical for fetal protection.[13,18] After surgery, a

transvaginal ultrasound was performed to assess for potential subchorionic hemorrhage—a known risk factor for miscarriage following surgical and anesthetic procedures. The ultrasound revealed no such findings.

Postoperatively, progesterone was administered to support pregnancy maintenance, particularly in cases where surgical or anesthetic stress might trigger uterine contractions or increase miscarriage risk. Progesterone plays a vital role in stabilizing the endometrium, suppressing uterine contractility, and supporting optimal fetal development during the early, critical stages of pregnancy.[10]

Through a multidisciplinary approach, the use of TCI propofol proved effective in maintaining maternal stability during surgery while also creating favorable intraoperative conditions for fetal well-being. The successful placement of the VP shunt provided a favourable prognosis for the mother by preventing further neurological deterioration, while simultaneously minimizing potential risks to the fetus.[13,19]

Postoperative maternal monitoring included continuous evaluation of vital signs, neurological assessments, and surveillance for potential complications such as infection, bleeding, or cerebrospinal fluid leakage. Fetal monitoring involved serial ultrasonographic evaluations to ensure appropriate growth consistent with gestational age and to assess uteroplacental blood flow, which may be influenced by surgical and anesthetic interventions. This ongoing surveillance is essential for the early detection of any postoperative or anesthetic-related complications.[20]

CONCLUSION

The use of TCI propofol anesthesia in a 5-week pregnant patient undergoing VP shunt placement for hydrocephalus proved to be an appropriate and effective choice. Propofol provided optimal cerebral conditions—offering neuroprotective effects and lowering ICP—while remaining safe for the fetus when used for short-term exposure. Compared to sevoflurane, propofol demonstrated superior capacity in preserving cerebral autoregulation and reducing the incidence of postoperative nausea and vomiting (PONV), although both agents are considered safe for use during pregnancy. Adjunctive medications such as fentanyl, atracurium, and lidocaine played vital roles in the anesthetic plan, each contributing to analgesia, muscle relaxation, and suppression of airway reflexes, respectively. All were administered at standard clinical doses known to pose minimal risk to fetal development. Unique neuro-obstetric challenges—including ventilatory control, patient positioning, and intraoperative monitoring were successfully managed through careful anesthetic strategy and perioperative planning.

As a result, the VP shunt procedure was carried out safely, preventing further neurological deterioration in the mother while preserving fetal well-being during this critical gestational period.

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