PAR Perioperative Anesthesia Reports

CASE REPORT WITH LITERATURE REVIEW

Anesthesia for robotic HITHOC surgery in a patient with pulmonary sarcoma: case report and literature review

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ABSTRACT

Hyperthermic intrathoracic chemotherapy (HITHOC) combined with cytoreductive surgery is an emerging treatment for selected pleural malignancies but poses major anesthetic challenges related to hyperthermia, one-lung ventilation, hemodynamic instability, and cisplatin-associated nephrotoxicity. The anesthetic management of robotic-assisted HITHOC remains poorly described. We report the perioperative management of a 61-year-old man with pulmonary metastatic leiomyosarcoma who underwent robotic cytoreductive surgery followed by HITHOC. Advanced hemodynamic monitoring, lung-protective ventilation, deep neuromuscular blockade, goal-directed fluid therapy, and nephroprotective strategies were used throughout the procedure. The patient remained hemodynamically stable without major intraoperative complications or postoperative renal dysfunction. This case highlights important anesthetic considerations for robotic HITHOC and emphasizes the role of individualized monitoring and multidisciplinary perioperative management in complex thoracic oncologic surgery.

KEYWORDS

HITHOC; hyperthermic intrathoracic chemotherapy; robotic surgery; anesthetic management; pulmonary leiomyosarcoma; case report

INTRODUCTION

Hyperthermic intrathoracic chemotherapy (HITHOC) combined with cytoreductive surgery is an emerging multimodal treatment for malignant pleural tumors, including primary pleural mesothelioma, thymoma with pleural dissemination, and selected cases of secondary pleural metastases[1,2]. The procedure involves the instillation of heated chemotherapeutic agents (typically cisplatin at 42°C) into the pleural cavity following surgical cytoreduction, aiming to achieve local tumor control through the synergistic cytotoxic effects of hyperthermia and chemotherapy[2].

Despite favorable oncological outcomes reported in several series, HITHOC poses significant physiological challenges for the anesthesiologist. The application of hyperthermic agents to the thorax results in vasodilatation, cardiac warming, and compression of mediastinal vessels, potentially leading to abrupt hemodynamic changes including sudden drops in cardiac output and increases in pulmonary vascular resistance[2]. Additionally, the use of cisplatin carries a substantial risk of nephrotoxicity, requiring proactive nephroprotective strategies[3].

The combination of robotic-assisted surgery with HITHOC represents a further evolution of this technique. Romano et al.[4] evaluated the safety of robotic pleurectomy combined with HITHOC in nine patients with thymoma relapses or malignant pleural mesothelioma, reporting no intraoperative complications and no renal complications related to perfusion. Robotic thoracic surgery introduces additional anesthetic considerations, including intrathoracic carbon dioxide insufflation, prolonged one-lung ventilation, and

the need for deep neuromuscular blockade to maintain stability during robotic manipulation[5]. However, the anesthetic management of robotic HITHOC remains poorly described in the literature, particularly in the context of metastatic pulmonary sarcoma.

This case report describes the perioperative anesthetic strategy employed for a robotic-assisted HITHOC procedure, with emphasis on how advanced monitoring modalities directly informed clinical decisions, and also reviews the current evidence on key aspects of anesthetic management.

CASE REPORT

A 61-year-old male (78 kg, 175 cm, BMI 25.5 kg/m^2, ASA III) was referred for robotic cytoreductive surgery followed by HITHOC due to progressive pulmonary metastasis from a high-grade leiomyosarcoma of the right arm (T1N0M1). His medical history included systemic arterial hypertension, dyslipidemia, depressive disorder, and cervical disc herniation. Chronic medications consisted of venlafaxine, quetiapine, pregabalin, oxycodone, atorvastatin, and losartan. Family history was notable for colorectal and gastric malignancies.

The oncological course included surgical resection of the primary tumor, followed by confirmation of pulmonary metastasis. The patient underwent seven cycles of doxorubicin with partial response; however, subsequent imaging demonstrated disease progression with pleural involvement. After multidisciplinary discussion, robotic cytoreductive surgery combined with HITHOC was indicated.

A comprehensive preoperative assessment was performed. Laboratory evaluation demonstrated hemoglobin of 13.2 g/dL and platelet count of 245,000/µL, with preserved renal function (creatinine 0.9 mg/dL, eGFR >90 mL/min/1.73 m^2), normal hepatic function, and normal coagulation profile (INR 1.0, aPTT 28 s). Electrolytes were within normal limits, including sodium 140 mEq/L, potassium 4.2 mEq/L, and magnesium 2.0 mg/dL.

Pulmonary function testing revealed FEV_1 82% predicted and FVC 85% predicted, with an FEV_1/FVC ratio of 0.76, consistent with a mild obstructive pattern. Chest computed tomography combined with scintigraphy demonstrated multiple pleural nodules in the right hemithorax without contralateral disease. Cardiological evaluation showed preserved left ventricular ejection fraction (62%) without valvular abnormalities or pulmonary hypertension, and electrocardiography demonstrated sinus rhythm without ischemic changes. Functional capacity was greater than 4 metabolic equivalents.

After multidisciplinary oncological discussion, robotic cytoreductive surgery combined with HITHOC was indicated for local pleural disease control. Preoperative risk was classified as intermediate, and the patient was considered ASA III.

Anesthetic management

Preoperative pharmacological management included continuation of venlafaxine until the day of surgery to avoid discontinuation syndrome, while oxycodone was withheld on the morning of surgery. Anxiolysis was achieved with midazolam 2 mg intravenously, and antithrombotic prophylaxis was initiated with enoxaparin 40 mg subcutaneously on the evening before surgery.

A thoracic epidural catheter was placed at the T9–T10 interspace using a loss-of-resistance technique in the sitting position. A test dose of 3 mL of 2% lidocaine with epinephrine (1:200,000) was administered to exclude intravascular or intrathecal placement. An initial bolus of 15 mL of 0.3% ropivacaine with 100 µg fentanyl achieved a sensory block from T6 to L1.

General anesthesia was induced using target-controlled infusion of propofol (Eleveld model, target effect-site concentration 4.0 µg/mL) and remifentanil (Minto model, target effect-site concentration 4.0 ng/mL). Neuromuscular blockade was achieved with rocuronium 0.6 mg/kg, and a left-sided double-lumen endobronchial tube (37 Fr) was placed under fiberoptic guidance.

In addition to standard ASA monitoring, advanced monitoring included invasive arterial blood pressure via a left radial artery catheter and central venous access via the right internal jugular vein under ultrasound guidance. Depth of anesthesia was monitored using bispectral index with a target range of 40–60. Cerebral oximetry (Foresight) was applied bilaterally, with baseline values of 68% on the right and 71% on the left, and an intervention threshold defined as a decrease greater than 20% from baseline.

Advanced hemodynamic monitoring was performed using the Acumen sensor connected to the Hemosphere platform, allowing continuous assessment of cardiac output, stroke volume variation, and systemic vascular resistance. Core temperature was monitored via esophageal and nasopharyngeal probes, while urine output was continuously measured with a target above 1 mL/kg/h. Serial arterial blood gas analysis was performed every 30 minutes during the HITHOC perfusion phase.

Anesthesia was maintained with target-controlled infusion of propofol (effect-site concentration 2.5–3.5 µg/mL) and remifentanil (2.0–4.0 ng/mL), titrated to maintain bispectral index values between 40 and

60. Continuous epidural infusion of 0.2% ropivacaine at 6 mL/h was maintained throughout the procedure.

During the robotic phase, one-lung ventilation was instituted using a protective strategy with tidal volume of 5 mL/kg predicted body weight, positive end-expiratory pressure of 5 cmH_2O, and respiratory rate adjusted to maintain $PaCO_2$ between 35 and 45 mmHg. FiO_2 was titrated to maintain SpO_2 above 92%, starting at 0.6, and peak inspiratory pressure was limited to 30 cmH_2O. Recruitment maneuvers were performed following re-expansion of the collapsed lung[6,7].

During the HITHOC perfusion phase, consisting of intrathoracic administration of cisplatin at 42°C for 60 minutes using 6 liters of heated saline, a hyperdynamic circulatory response was observed. Mean arterial pressure decreased from 75 to 65 mmHg within the first 15 minutes, consistent with vasodilatation induced by hyperthermia. Systemic vascular resistance decreased from 1,100 to 850 $dyn \cdot s \cdot cm^{-5}$, while cardiac output increased from 5.2 to 6.1 L/min.

Stroke volume variation increased from 8% to 14%, triggering a goal-directed fluid bolus of 250 mL of Plasmalyte (threshold >13%), which restored SVV to 10%. The bispectral index remained within the target range (42–55); however, the increase in cardiac output required upward titration of propofol effect-site concentration from 2.5 to 3.2 µg/mL to maintain adequate anesthetic depth, reflecting altered pharmacokinetics in the hyperdynamic state.

Cerebral oximetry values remained stable, ranging from 65–70% on the right and 68–73% on the left, with no episodes exceeding the predefined intervention threshold, indicating preserved cerebral oxygenation. Low-dose norepinephrine infusion (0.03–0.05 $\mu g \cdot kg^{-1} \cdot min^{-1}$) was initiated when mean arterial pressure decreased below 65 mmHg and was titrated to maintain adequate perfusion.

Total intraoperative fluid administration was 4,000 mL of Plasmalyte (approximately 6.4 mL/kg/h over 8 hours), with estimated blood loss of 300 mL and no requirement for transfusion.

Thermal management included the use of a forced-air warming blanket during the surgical phase, which was removed during HITHOC to prevent excessive hyperthermia. Core temperature was continuously monitored and peaked at 37.8°C (esophageal) and 37.5°C (nasopharyngeal), without the need for active cooling.

Nephroprotective strategies included preoperative hydration with 1,000 mL of normal saline over two hours, maintenance of urine output above 1 mL/kg/h (mean 1.3 mL/kg/h during HITHOC), avoidance of nephrotoxic agents, and intravenous magnesium supplementation (2 g over one hour), in accordance with current recommendations[3,8,9].

Antiemetic prophylaxis consisted of ondansetron 4 mg and dexamethasone 4 mg administered intravenously, given the high emetogenic potential of cisplatin[10].

Total surgical duration was eight hours, including one hour of HITHOC perfusion. Neuromuscular blockade was reversed with sugammadex 2 mg/kg, and the patient was extubated in the operating room after meeting standard criteria, including adequate tidal volume, respiratory rate of 20 breaths per minute, SpO_2 above 95% on FiO_2 0.4, bispectral index above 80, and train-of-four ratio greater than 0.9.

The patient was transferred to the intensive care unit for monitoring. Postoperative analgesia was maintained with continuous epidural infusion of 0.2% ropivacaine with fentanyl (2 µg/mL) at 6 mL/h, supplemented with intravenous paracetamol and dipyrone. Pain scores were 3/10 at rest and 5/10 with coughing at six hours.

At 24 hours, laboratory evaluation demonstrated hemoglobin 11.8 g/dL, creatinine 1.0 mg/dL, potassium 3.8 mEq/L, magnesium 1.8 mg/dL, lactate 1.2 mmol/L, and normal arterial blood gas values.

The epidural catheter was maintained for 72 hours. The patient was mobilized on postoperative day one, transitioned to oral analgesia on day three, and discharged on postoperative day seven without complications. At the 30-day follow-up, renal function remained preserved, and imaging at three months demonstrated stable disease

A structured summary of perioperative management is presented in Table 1.

DISCUSSION

This case illustrates the complex anesthetic management required for robotic-assisted HITHOC, a procedure that combines the challenges of prolonged robotic thoracic surgery with the physiological derangements induced by intrathoracic hyperthermic chemotherapy perfusion. While previous reports have described anesthetic management in conventional open HITHOC, the present case is notable for several reasons[1,2].

First, it describes the anesthetic management of robotic-assisted HITHOC for metastatic pulmonary leiomyosarcoma, a rare indication that combines the hemodynamic challenges of hyperthermic perfusion with the ventilatory and positioning demands specific to robotic thoracic surgery, including prolonged one-lung ventilation and the potential need for intrathoracic CO_2 insufflation[5]. Second, the integration of multiple advanced monitoring modalities — including pulse contour analysis (Acumen/ Hemosphere), cerebral oximetry (Foresight),

Table 1. Perioperative management protocol for HITHOC (Hyperthermic Intrathoracic Chemotherapy), including phase-specific strategies, anesthetic interventions, monitoring modalities, and predefined clinical targets used throughout the perioperative period.

Phase	Strategy	Specific interventions	Monitored parameters and thresholds
Preoperative	Risk assessment	Spirometry, echocardiography, renal function, electrolytes	FEV_1 82%, LVEF 62%, creatinine 0.9 mg/dL, eGFR >90 mL/min/1.73 m^2
Preoperative	Medication management	Venlafaxine continued; oxycodone held; enoxaparin 40 mg SC	—
Preoperative	Nephroprotection initiation	Pre-hydration with 1,000 mL NaCl 0.9% over 2 h	Urine output target >1 mL/kg/h
Intraoperative	Neuraxial analgesia	Epidural T9–T10; ropivacaine 0.3% 15 mL + fentanyl 100 µg	Sensory level T6–L1
Intraoperative	General anesthesia	TCI propofol (Eleveld) + remifentanil (Minto); rocuronium 0.6 mg/kg	BIS target 40–60
Intraoperative	Airway management	Left DLT 37 Fr; fiberoptic confirmation	SpO_2 >92%; PIP ≤30 cmH_2O
Intraoperative	Advanced monitoring	Acumen/Hemosphere, BIS, Foresight (bilateral), dual-site temperature	SVV threshold >13%; cerebral oximetry >20% decrease from baseline
Intraoperative	Hemodynamic management during HITHOC	Goal-directed fluid boluses (250 mL Plasmalyte when SVV >13%); norepinephrine 0.03–0.05 $\mu g \cdot kg^{-1} \cdot min^{-1}$	MAP >65 mmHg; CO; SVR
Intraoperative	Thermal management	Forced-air warming during surgical phase only; removed during HITHOC	Esophageal and nasopharyngeal temperature; peak 37.8°C
Intraoperative	Protective ventilation (OLV)	TV 5 mL/kg PBW; PEEP 5 cmH_2O; FiO_2 0.6; recruitment maneuvers post re-expansion	$PaCO_2$ 35–45 mmHg; SpO_2 >92%
Intraoperative	Nephroprotection	Magnesium 2 g IV; avoidance of nephrotoxins; urine output monitoring	Urine output >1 mL/kg/h (mean 1.3 mL/kg/h during HITHOC)
Postoperative	Analgesia	Epidural ropivacaine 0.2% + fentanyl 2 µg/mL at 6 mL/h; IV paracetamol + dipyrone	VAS ≤3/10 rest, ≤5/10 coughing at 6 h
Postoperative	Renal monitoring	Serial creatinine, electrolytes, urine output	Creatinine 1.0 mg/dL at 24 h (baseline 0.9)
Postoperative	Respiratory care	Early mobilization POD 1; chest X-ray POD 2	SpO_2 >95% on 2 L/min; no pneumothorax

BIS: bispectral index; CO: cardiac output; DLT: double-lumen tube; FiO_2: fraction of inspired oxygen; HITHOC: hyperthermic intrathoracic chemotherapy; MAP: mean arterial pressure; OLV: one-lung ventilation; PBW: predicted body weight; PEEP: positive end-expiratory pressure; PIP: peak inspiratory pressure; POD: postoperative day; SVR: systemic vascular resistance; SVV: stroke volume variation; TCI: target-controlled infusion; TV: tidal volume; VAS: Visual Analog Scale.

and processed electroencephalography (BIS) in a single HITHOC case has not been previously described and enabled real-time correlation between physiological changes and clinical interventions. Third, the structured approach to cisplatin nephroprotection, incorporating prehydration, magnesium supplementation, and goal-directed urine output monitoring in the context of intrathoracic (rather than intraperitoneal) administration, contributes to the limited evidence on renal protection during HITHOC[3].

The hemodynamic effects observed in this case are consistent with previously described physiological responses to hyperthermic intrathoracic chemotherapy, including vasodilatation, increased cardiac output, decreased systemic vascular resistance, and potential cardiac compression from the perfusate volume[2]. Kim et al.[2] reported abrupt hemodynamic changes during intrapleural hyperthermic chemotherapy, including reductions in cardiac output and increases in pulmonary vascular resistance. In the present case,

advanced hemodynamic monitoring detected the expected decrease in systemic vascular resistance (from 1,100 to 850 dyn·s·cm^{-5}) and compensatory increase in cardiac output (from 5.2 to 6.1 L/min) within the first 15 minutes of perfusion. The increase in stroke volume variation to 14% triggered a protocol-guided fluid bolus, while the concurrent decrease in mean arterial pressure below 65 mmHg prompted initiation of low-dose norepinephrine. This management approach aligns with previous reports demonstrating that invasive cardiac output monitoring allows more precise titration of fluid therapy during HITHOC and that vasopressor support is frequently required during the perfusion phase[2,11].

Cerebral oximetry provided an additional safety layer by confirming preserved cerebral oxygenation, with values remaining within 5% of baseline despite significant hemodynamic fluctuations. Processed EEG monitoring was particularly relevant during the hyperdynamic phase, as the hyperthermia-induced increase in cardiac output likely altered pharmacokinetics, necessitating upward titration of propofol to maintain adequate anesthetic depth[12].

Fluid management during hyperthermic chemotherapy remains a critical determinant of outcomes. Evidence suggests that excessive fluid administration is associated with increased morbidity; Eng et al. [13] demonstrated that patients receiving more than 15.7 mL/kg/h experienced a 43% increase in complications during CRS/HIPEC. Conversely, Colantonio et al. reported that goal-directed fluid therapy significantly reduced major complications compared with standard fluid strategies (10.5% vs. 38.1%, $p = 0.005$)[14]. In the present case, stroke volume variation-guided fluid management resulted in a total crystalloid administration of approximately 6.4 mL/kg/h, consistent with a restrictive, physiology-driven approach supported by current evidence[4,15].

Cisplatin-based HITHOC is associated with a substantial risk of renal toxicity. Markowiak et al.[3] reported renal complications in 34.5% of patients undergoing HITHOC, although adequate perioperative management significantly mitigated severity. In addition, Gupta et al.[16] demonstrated that prophylactic intravenous magnesium was associated with a reduced risk of cisplatin-associated acute kidney injury, while Nieto-Elizalde et al.[17] identified low urine output during hyperthermic perfusion as an independent predictor of renal dysfunction (OR 3.36, 95% CI 1.68–6.71). In the present case, the combination of prehydration, magnesium supplementation, avoidance of nephrotoxic agents, and maintenance of urine output above 1 mL/kg/h was associated with preserved postoperative renal function (creatinine 1.0 mg/dL vs. baseline 0.9 mg/dL).

Thermal control was effectively achieved, with peak core temperature of 37.8°C, well below thresholds associated with systemic complications, reflecting the effectiveness of dual-site monitoring and phase-specific warming strategies[12]. Protective ventilation during one-lung ventilation, using low tidal volume and moderate PEEP, was applied in accordance with evidence from the iPROVE-OLV trial, which demonstrated reduced postoperative pulmonary complications with individualized open-lung strategies[6]. No pulmonary complications were observed in this case.

This report has inherent limitations. It describes a single case, and therefore its findings cannot be generalized. In addition, the absence of standardized anesthetic protocols for robotic HITHOC limits direct comparison with other centers. Finally, long-term oncological outcomes were not assessed within the scope of this report.

CONCLUSION

The anesthetic management of robotic-assisted HITHOC requires a comprehensive, individualized, and multidisciplinary approach. This case demonstrates that the integration of advanced hemodynamic monitoring (Acumen/Hemosphere, cerebral oximetry, BIS) with goal-directed fluid therapy, proactive thermal management, cisplatin nephroprotection, protective lung ventilation, and epidural-centered multimodal analgesia enables real-time, monitoring-guided clinical decision-making and can contribute to favorable perioperative outcomes in this complex oncologic procedure.

Patient perspective

The patient reported satisfaction with the perioperative care, particularly highlighting effective pain control and the absence of nausea or vomiting. At the 30-day follow-up, he expressed willingness to undergo the procedure again if clinically indicated.

Informed consent

Written informed consent was obtained from the patient for publication of this case report, including all clinical data. No identifying images are included.

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