Multimodal anesthesia for hemicorporectomy suggests creating a standardized anesthesia guideline: a case report

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Background: First performed in 1960, hemicorporectomy, or translumbar amputation, is a rare surgery performed as a last resort for patients with life-threatening diagnoses. While rare, it is associated with significant challenging events for the anesthesiologist. Here we present a challenging hemicorporectomy case which was successfully managed using a multimodal anesthesia approach.

Case Description: The patient was a 40-year-old patient presenting for completion of a hemicorporectomy via a left hemipelvectomy for pelvic chondrosarcoma. The patient underwent hemicorporectomy under epidural and total intravenous anesthesia supplemented with ketamine and lidocaine infusion. The surgery lasted 17.5 h and resulted in 28 L of blood loss. The patient noted excellent pain control and was discharged on postoperative day 74 following an uncomplicated hospital course and in-house rehabilitation.

Conclusions: Reviewing the literature, we recognized that there are no standardized anesthesia protocols published for hemicorporectomy. Based on our case report we present a novel anesthesia strategy that addresses almost all major challenges with hemicorporectomies. Our successful strategy suggests that a total intravenous anesthesia with propofol in combination with an epidural and a multimodal pain regimen with rate adjustments based on body mass reduction should be considered as a standard anesthesia protocol for hemicorporectomies. We recommend establishing a state-of-the-art anesthesia guideline for patients undergoing hemicorporectomy and encourage anesthesiologists to publish case reports describing the anesthesia approach for a hemicorporectomy.

Keywords: Hemicorporectomy; anesthesia; guideline; multimodal; case report

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Introduction

Background

Hemicorporectomy, also known as translumbar amputation, is a two-stage procedure including disarticulation of the lumbar spine along with transection of the aorta, inferior vena cava, spinal cord and creation of urinary and fecal conduits (1,2). The anterior-to-posterior method has been the standard surgical technique since 1960 but is associated with significant blood loss, morbidity, and prolonged hospital stays (1,2). Recently, posterior-to-anterior approaches have been attempted with hopes of reducing

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blood loss and neurogenic hypotension (1,2). Nevertheless, hemicorporectomies pose a difficult challenge for anesthesiologists because of extreme physiologic changes such as massive fluid shifts, neurogenic and hemorrhagic shock, and hypothermia following significant body mass loss (3,4).

Rationale and knowledge gap

In this case report, we present a challenging hemicorporectomy case that lasted 17.5 h with 28 L of blood loss. We were unable to find any case reports in the literature describing a similar scenario, and we were also unable to find a previous report of a hemicorporectomy attempting to propose an anesthesia protocol that could be used as a guideline for hemicorporectomies. In contrast, there is an abundance of literature describing the complexity of the surgical procedure (4-9).

Objective

We will discuss the challenges during anesthesia for a hemicorporectomy and possible treatment options. We will further discuss the establishment of a standardized anesthesia protocol for hemicorporectomies. We present this case in accordance with the CARE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-24-174/rc).

Highlight box

Key findings

- We present a challenging hemicorporectomy case that lasted 17.5 h with 28 L of blood loss.
- Using a multimodal anesthesia approach with epidural anesthesia, total intravenous anesthesia, ketamine, methadone and lidocaine we were able to successfully complete the case and provide excellent postoperative pain control.

What is known and what is new?

- Hemicorporectomy and hemipelvectomy are rare cases, have a high mortality rate and are challenging for the anesthesiologist.
- Using a multimodal total intravenous anesthesia with rate adjustments based on body mass reduction in combination with a neuraxial anesthesia approach addressing the most common challenges resulted in a hemodynamically stable procedure with excellent pain control thereafter.

What is the implication, and what should change now?

- Our successful strategy suggests that a multimodal total intravenous anesthesia with rate adjustments based on body mass reduction in combination with a neuraxial anesthesia should be considered as standard for hemicorporectomies.
- We recommend establishing a state-of-the-art anesthesia guideline for patients undergoing hemicorporectomy.

Case presentation

We report the perioperative management of a 40-year-old, 65.3 kg man, ASA III (American Society of Anesthesiologists Physical Status Classification) presenting for completion of a hemicorporectomy via a left hemipelvectomy for pelvic chondrosarcoma {stage III [rT3(m)], N0, M0, G3}. His surgical history was notable for a right-sided hemipelvectomy (performed 9 months prior) and a left hemipelvectomy, sigmoid colon ureteral conduit/neobladder creation by urology, end colostomy, proctectomy and bladder resection (stage 1 of this procedure, completed 16 days prior, see timeline in *Figure 1*). His comorbidities included a history of hereditary multiple exostosis, chronic cancer-related pain treated with opioids [120 morphine milligram equivalents (MME) per day], provoked deep vein thrombosis (DVT) in the perioperative setting not on anticoagulation, and a history of traumatic brain injury without residual deficits.

The patient was admitted one week before the scheduled surgery for optimization of his chronic pain. Due to the complexity of the case, a multidisciplinary board coordinated the care. The board included Trauma and Acute Care Services, Hospitalist Medicine, Physical Medicine and Rehabilitation, Orthopedic Spine Surgery, Acute Pain Service, Plastic Surgery, Psychiatry, Palliative Care, and Urology. Preoperative line placement included a multi lumen access catheter (MAC) in the right internal jugular vein for central venous access and for rapid fluid and blood product administration and a right radial arterial line for hemodynamic monitoring. The day of surgery, a T11–T12 epidural catheter was successfully placed using a paramedian approach. Induction of anesthesia was performed using midazolam 2 mg, fentanyl 250 mcg, propofol 250 mg, and rocuronium 100 mg. Direct laryngoscopy was performed and an endotracheal tube was placed without complication.

After induction, the patient underwent a hemicorporectomy, a L4–L5 posterior spinal cord amputation, a left myofasciocutaneous thigh flap, removal of pelvis, removal of genitalia, complex tissue rearrangement, and complex wound closure. For maintenance of anesthesia, continuous intravenous (IV) infusions of propofol (total of 7,950 mg), sufentanil (total of 380 µg), ketamine (total of 320 mg), lidocaine (total of

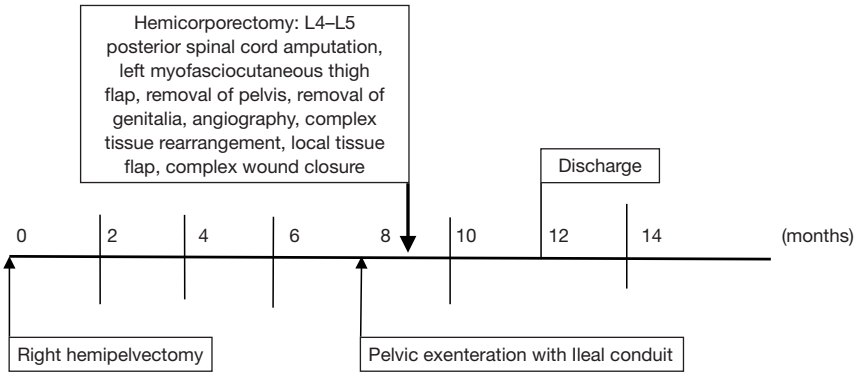

Figure 1 Timeline. Overview of surgical procedures performed prior to hospital discharge.

Table 1 Intraoperative maintenance infusion rate adjustments based on body mass reduction through hemicorpectomy surgery progression

Medication	Initial infusion rate	Infusion rate after distal lower extremity disarticulation	Infusion rate after proximal lower extremity disarticulation	Final infusion rate
Tranexamic acid (TXA), mg/kg/h	1	0.9	0.8	0.8
Lidocaine, mg/kg/h	1	1	0.8	0.8
Ketamine, mg/h	20	20	20	15
Sufentanil, mcg/kg/h	0.1	0.3	0.1	0.1
Propofol, mcg/kg/min	125	140	140	125
Rocuronium, mg/h	60	60	100	100

795 mg), rocuronium (total of 250 mg), and tranexamic acid (total of 1,922 mg) were administered. To avoid potential toxicity, lidocaine and tranexamic acid infusions were titrated relative to the patient's body mass removed as reflected in *Table 1*. The surgical procedure lasted 17.5 hours with an estimated 28 L blood loss. Transfusion totals included: 47 units of packed red cells, 2 units of platelets, 48 units of fresh frozen plasma, 4.7 L of crystalloid, and 2.5 L of 5% albumin. A high flow fluid warmer was used for fluid and blood product administration. The urine output was 1.8 L and he was 6 L net positive at closure. Despite the massive transfusion of blood products and the extraordinary length of the procedure, the vital signs remained remarkably stable throughout (*Figure 2*).

The patient remained intubated postoperatively and was admitted to the surgical trauma intensive care unit on propofol sedation. The patient was extubated on postoperative day (POD) 1. Postoperative pain was managed using an epidural infusion of 30 mg/mL hydromorphone and 0.125% bupivacaine along with his home regimen of gabapentin 900 mg quater in die (QID) and MS Contin 60 mg bis in die (BID). On POD 1, the patient noted excellent pain control with the epidural infusion. Postoperatively, his opiate needs increased to 180 MME per day in addition to the epidural infusion. He was transferred to the floor on POD 3 and the epidural was removed on POD 7. He was discharged on POD 74 following an uncomplicated hospital course and in-house rehabilitation. Unfortunately, despite the reported optimized management in the perioperative period, the patient's cancer worsened over the following two years post-surgery and care was eventually withdrawn and the patient passed away.

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committees and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

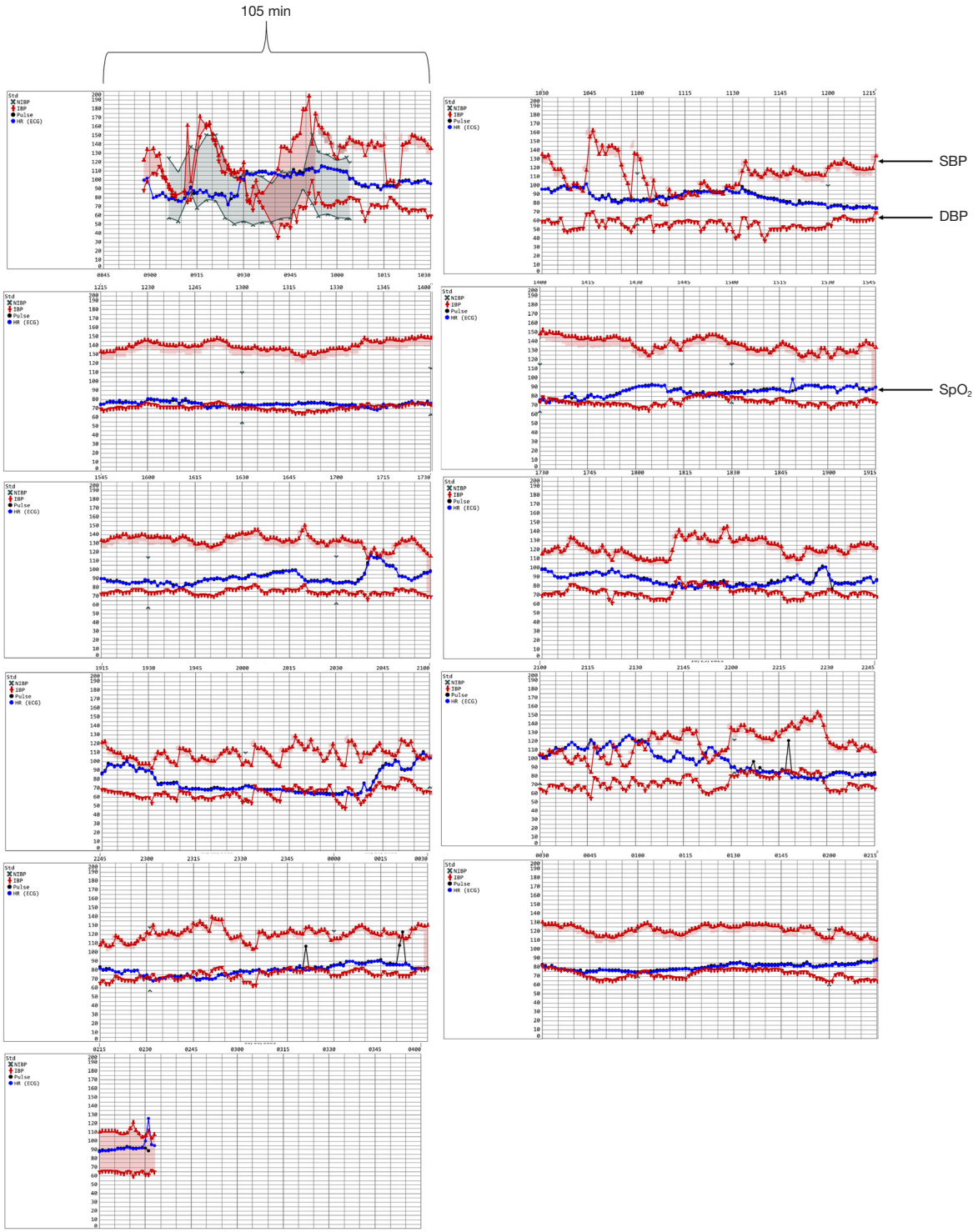

Figure 2 Anesthesia timeline. Overview of blood pressure and oxygen saturation over the course of a 17.5 h hour hemicorporectomy surgery. Note: patient was remarkable hemodynamically stable throughout. DBP, diastolic blood pressure; ECG, electrocardiogram; HR, heart rate; IBP, invasive blood pressure; NIBP, non-invasive blood pressure; SBP, systolic blood pressure; SpO_2, peripheral oxygen saturation.

Discussion

Key findings

Hemicorporectomies are difficult cases for anesthesiologists to manage as removal of significant body mass can lead to massive and rapid fluid shifts, electrolyte and acid-base imbalances, hemorrhagic shock, or neurogenic shock following transection of the spinal cord (2,9-11). These physiologic derangements in combination can lead to significant and difficult to manage hypotension (3,9,11). Authors in the 1980s to 2000s advocated for the use of epidural morphine or infiltration of local anesthetic into the cauda equina prior to the transection to prevent hemodynamic instability secondary to neurogenic shock (10,11). We opted for a modernized epidural-based technique to mitigate intraoperative neurogenic shock with the added benefit of postoperative pain control. Indeed, hemodynamic stability (*Figure 2*) and excellent postoperative pain control were achieved in our patient.

During a hemicorporectomy, body mass is decreased by ~33% to 55% and the blood volume is reduced to a lesser degree, creating an opportunity for significant fluid overload (2,9-11). This imbalance can lead to postoperative pulmonary edema and subsequent challenging ventilator management; pulmonary edema is a common cause of death in early reports of hemicorporectomy (2,3,11). Interestingly, despite loss of tissue, oxygen consumption remains elevated through the early postoperative period and is eventually reduced ~12% by the third postoperative week (11). Moreover, total lung capacity decreases by 37%, vital capacity decreases by 40%, and functional residual capacity decreases by 52% postoperatively (2,11). In addition to these physiological changes, significant blood loss during surgery is to be expected. Fortunately, despite massive resuscitation and transfusion, our patient did not experience any pulmonary complications and had the benefit of an early extubation. We attributed this success to our epidural analgesia in combination with a multimodal pain regimen including methadone, ketamine, and lidocaine to optimize the treatment of postoperative pain while reducing daily MME and associated side effects.

As hemicorporectomies are highly complex, invasive and ethically sensitive a multidisciplinary board who oversees and coordinates the care is paramount. In this case, the board consisted of Trauma and Acute Care Services, Hospitalist Medicine, Physical Medicine and Rehabilitation, Orthopedic Spine Surgery, Acute Pain Service, Plastic Surgery, Psychiatry, Palliative Care, and Urology. A few months ahead of time a detailed care plan was created by the multidisciplinary board in collaboration with the patient and family.

Explanations of findings

As shown by a randomized double-blinded clinical trial of patients undergoing cardiac surgery, intraoperative methadone resulted in reduced postoperative morphine requirements, improved pain scores, and enhanced patient-perceived quality of pain management (12). Similarly, a study on patients undergoing complex spine surgery also found that perioperative treatment with a single bolus of methadone improved postoperative pain control (13). Based on the complexity of hemicorporectomy as in the above-mentioned cases, we believe methadone should be an integral part of the anesthetic plan for a hemicorporectomy. However, we would like to point out that respiratory depression can be enhanced with methadone under certain circumstances (14). As such careful clinical reasoning, expert knowledge, and reflective practice needs to be performed for each individual case.

Multimodal analgesia is readily available, and the evidence is strong to support its efficacy (15): ketamine as adjunct has been shown to reduce postoperative opioid requirements and associated side effects and decrease the incidence of worsened chronic postoperative pain (16). Similarly, lidocaine infusion as additive to general anesthesia during mastectomies for breast cancer reduced the incidence of chronic pain postoperatively, postoperative acute pain intensity, and intraoperative opioid requirements (17). Additionally, lidocaine reduces serum inflammatory markers, which has been associated with decreased risk of cancer recurrence in some patients, supported by *in vitro* and retrospective data (17,18). Based on this evidence for ketamine and lidocaine use, in a multimodal analgesia approach or in cancer patients we added both drugs. Based on their low risk profile we also believe both drugs could become standard of care when performing anesthesia for a hemicorporectomy. Indeed, a meta-analysis revealed that perioperative lidocaine infusion reduces postoperative pain and opioid requirement, as well as ileus recovery time, hospital length of stay, and nausea/vomiting (14). However, considering that toxic levels were detected and that adverse events were not systematically screened for in most studies, dose and safety of IV lidocaine has not fully been established yet. As such careful clinical judgment needs to be executed for each individual case.

Although dexmedetomidine possesses anti-inflammatory

properties and reduces postoperative opiate requirements as part of a multimodal analgesia approach, it was avoided for this patient due to emerging data from retrospective studies and *in vivo* animal models that suggest dexmedetomidine can be associated with increased risk of cancer recurrence and metastatic conversion. In addition, dexmedetomidine can result in significant hypotension in high-risk patients (18-20). Based on the high risk for hypotension in this patient population and the other mentioned potential side effects, we believe dexmedetomidine should be avoided in hemicorporectomies.

In general, we believe this was an appropriate and successful pain management for our patient given that on POD 1 he reported a high satisfaction for his pain control. Notably, he reflected that the epidural infusion and boluses were the most helpful part of his whole regiment. He had minimal requirement of IV breakthrough medication while the epidural was in use. In addition, as the patient underwent a spinal cord dissection which could have resulted in a neurogenic shock, a neuraxial technique needed to be implemented regardless. We believe that titrating an epidural catheter to effect was key to success in preventing both significant hypotension and a neurogenic shock. As such the epidural catheter should become standard of care when performing anesthesia for a hemicorporectomy when indicated.

The total IV anesthesia with propofol was selected for this patient due to evidence that volatile gasses promote the release of cytokines, natural killer (NK) cells, and T cell modulation, which could worsen the cancer prognosis (18). Moreover, one study demonstrated that women undergoing mastectomy for breast adenocarcinoma under propofol total intravenous anesthesia (TIVA) had a significant reduction of local cancer recurrence, although there was no difference in metastatic conversion (18). In addition, the use of propofol infusion may reduce the overall blood loss during surgery even though clinical studies have been restricted to sinus surgeries so far (21). Overall, as there seems to be a benefit using propofol infusion for hemicorporectomy we suggest adding it to a standardized anesthesia protocol. However, while environmental and cancer related considerations have pushed for the use of propofol, recent meta-analysis indicated that propofol may reduce survival in perioperative and critically ill patients (22). While this outcome would need to be confirmed through a randomized prospective clinical trial, propofol should be used based on clinical judgment until then.

Comparison with similar case reports

We were unable to find any case reports in the literature describing a similar scenario, and we were also unable to find a previous report describing a detailed anesthetic plan for a patient undergoing hemicorporectomy. In fact, we only could find one case report describing the anesthetic plan. This case, however, described an emergent hemicorporectomy after hypovolemic shock and as such had very specific needs regarding anesthesia management (3). Our case is unique as it addresses the major challenges associated with hemicorporectomy. We believe that our protocol could be used as a guideline for future hemicorporectomies (*Figure 3*).

Another aspect of our anesthetic management that has not been previously reported in the hemicorporectomy literature is titration of infusions based on the progressive removal of body mass during the case (*Table 1*). As the disarticulation progressed, weight-based medications were adjusted to reflect the estimated decrease in weight. Using concepts from burn literature to guide our management, we estimated that the lower portion of the lower limb (foot and calf) accounted for ~10% of body mass, therefore medications were decreased ~10% with this disarticulation (23). We suspected that the upper portion of the lower limb (thigh and knee) accounted for another 10% and medications were adjusted accordingly. The volume of distribution of medications theoretically became increasingly dynamic with the removal of tissue and massive blood loss, requiring ongoing medication dosing changes. For additional data to assist with appropriate anesthetic titration in a dynamic surgical case, a processed electroencephalogram (EEG) monitor was used to monitor the impact of centrally acting medication titrations.

Limitations

One important limitation in cases with the potential of massive blood loss is an increased risk of low and unpredictable blood levels of IV anesthetics. As such strategies to avoid awareness may need to be implemented in such cases.

While there is some evidence of the use of propofol to improve outcomes in patients with cancer, it is limited to certain cancers so far. Similarly, while TIVA can reduce blood loss in sinus surgeries, major surgeries with massive blood loss have not been investigated yet.

Moreover, without prior studies or peer-reviewed data, it is difficult to evaluate the efficacy and safety of our

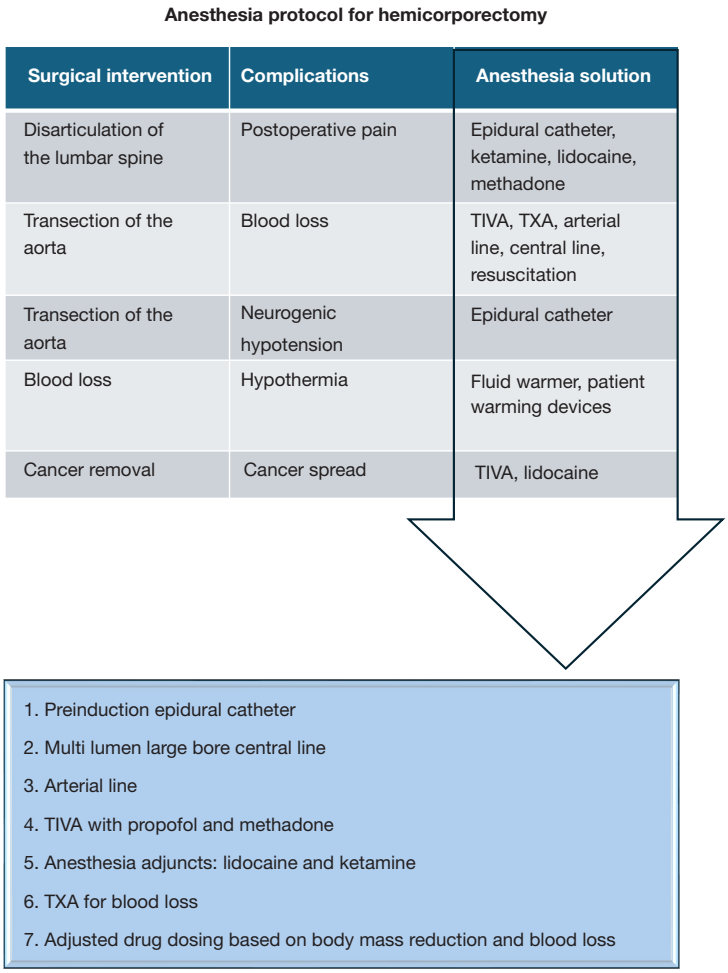

Figure 3 Proposed anesthesia protocol for hemicorporectomy management (this protocol is a practice advisory but is not intended to be a standard, or absolute requirement, and its use cannot guarantee any specific outcomes). TIVA, total intravenous anesthesia; TXA, tranexamic acid.

recommendations. However, as there is a limited number of cases worldwide it will be challenging to obtain outcome and safety data, regarding the anesthesia approach. As there is no description on the anesthesia approach for an elective hemicortectomy, we believe this information will be still useful for the anesthesia world. We hope that others follow this example and publish a detailed description on their anesthesia use for a hemicorporectomy to build a foundational body of evidence or create a dataset of cases to develop a case series scenario.

In general, hemicorporectomies are rare and as such each patient may need an individualized anesthesia plan, limiting the value of our proposed standardized anesthesia protocol. Nevertheless, we believe that a published standard guideline will be extremely helpful to the anesthesia community.

Conclusions

Implications and actions needed

In summary, this case highlights that corpectomies are extremely challenging cases for anesthesiologists. As such, it is quite surprising that there are no guidelines in the literature for such patients available yet. Based on the lack of a detailed anesthetic plan for these scenarios, a proposed pathway has been designed (*Figure 3*). We believe this protocol will be highly valuable to the anesthesia community.

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Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-24-174/rc

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