ELSEVIER

Clinical Research

Rectus Sheath Block Improves Patient Recovery Following Open Aortic Surgery

Colin Cleary,[1] Ya-Huei Li,[2] Akhilesh Jain,[3] Pranjali Kainkaryam,[4] Parth Shah,[3] Thomas Divinagracia,[3] James Gallagher III,[3] Elizabeth Aitcheson,[3] Mouhanad Ayach,[3] Kevin Finkel,[4] Owen Glotzer,[3] and Edward Gifford,[3] Farmington and Hartford, Connecticut

Background: Postoperative pain management remains a barrier to recovery following aortic surgery. Although epidural catheters help in adjunctive pain management, less is known about the use of rectus sheath blocks. We compared patient recovery following open abdominal aortic surgery (OAS) with and without adjunctive rectus block.

Methods: Adult patients undergoing open abdominal aortic aneurysm repair and aortobifemoral or aortoiliac bypass for occlusive disease were identified and stratified by use of general anesthesia alone (GA) versus adjunctive use of a rectus sheath block (GA + RB). A small number of patients with GA and concomitant epidural analgesia, along with patients that had retroperitoneal repairs, were not included in further analysis. Outcomes included time to extubation, intraoperative and postoperative morphine milligram equivalents (MME) utilization, length of stay, discharge MME, and postoperative complications. Categorial data were compared with Person Chi-Square tests or Fisher's exact tests. Continuous data were tested with independent *t*-tests or Mann−Whitney *U*-tests.

Results: From January 2017 to April 2022, there were 106 patients who underwent open aortic surgery, 55 patients with GA alone, 39 with GA + RB, and 12 patients who had a GA with concomitant epidural analgesia. Between GA and GA + RB, patients were comparable in both groups in terms of age, BMI (body mass index), smoking history, hypertension, diabetes, CAD (coronary artery disease), COPD (chronic obstructive pulmonary disease), and ASA (American Society of Anesthesiologists) class and prior opioid use. Patients with GA + RB were more likely to have scheduled elective procedures (80% GA cohort vs. 94.9% RB, $P = 0.040$), and a lower incidence of retroperitoneal exposure (14.5% GA cohort vs. 0% RB, $P = 0.019$). Patients with GA + RB had shorter time to extubation than GA (84.6% $<$ 12 hr vs. 44.4%, $P < 0.001$), greater rate of procedural ketamine usage (GA + RB: 61.5% vs. GA: 40.0%, $P = 0.049$), lower MME at first postoperative day (median MME GA + RB: 25.0 vs. GA: 67.5, $P = 0.002$), lower discharge MME (median MME GA + RB: 142.5 vs. GA: 225.0, $P = 0.036$), and overall shorter length of stay (median stay GA + RB: 5 vs. GA: 6 days, $P = 0.006$). Postoperative complications were similar between groups. Similar findings were found in the comparison between elective-only GA and GA + RB patients and after exclusion of patients who only had a single shot of regional anesthesia.

This study was presented as a podium presentation at the 2023 Vascular and Endovascular Surgery Society Winter Annual Meeting, February 23−26th.

Disclosures: AJ proctor, Terumo Aortic, Cook Medical; EG consultant, stock at Mavericks Endo, Inc.

[1]*University of Connecticut School of Medicine, Farmington, CT.*

[2]*Hartford Hospital Clinical Research Center, Hartford, CT.*

[3]*Division of Vascular Surgery, Hartford Hospital, Hartford, CT.*

[4]*Integrated Anesthesia Associates, Hartford, CT.*

Correspondence to: Edward D. Gifford, MD, FSVS, FACS, RPVI, Vascular and Endovascular Surgeon, Hartford HealthCare Heart and Vascular Institute, Hartford, CT, USA; E-mail: edward.gifford@hhchealth.org

Ann Vasc Surg 2023; ■: 1–10
https://doi.org/10.1016/j.avsg.2023.04.012

Manuscript received: February 25, 2023; manuscript accepted: April 11, 2023; published online: ■ ■ ■

Conclusions: Patients that receive adjunctive rectus sheath blocks for pain control following OAS utilize fewer opioid medications during hospital stay and at discharge. Rectus sheath blocks represent an alternative option to other periprocedural analgesia following open aortic surgery.

INTRODUCTION

Open abdominal aortic surgery presents with unique challenges for both intraoperative and postoperative analgesia. Administration of postoperative opioid oral or parenteral medication after general anesthesia has been shown to provide adequate pain management but does carry risk of persistent opioid use after discharge.[1] Regional blocks are utilized intraoperatively and postoperatively to reduce pain and opioid usage, which includes neuraxial anesthesia like epidural anesthesia, spinal anesthesia, paravertebral catheters, or rectus sheath block, among others.

Epidural-based analgesia has demonstrated effectiveness at providing postoperative pain control, with some evidence of improved time to ambulation, decreased odds of readmission, and shorter length of stay.[2] These findings are supported by a Cochrane review which found that use of epidurals in open abdominal aortic surgery was associated with decreased postoperative pain scores, duration of postoperative ventilation, and major postoperative complications.[3] However, there are limited data in support of other regional blocks in conferring postoperative pain relief, including rectus sheath block. As such, we were interested in the therapeutic potential of adjunctive rectus sheath blocks in open abdominal aortic surgeries for postoperative pain control and recovery to quantitatively assess its effectiveness in reducing opioid burden and improving other postoperative outcomes in our patient population.

METHODS

Study Design

A retrospective research study was conducted at a single regional teaching hospital to study patients who underwent open abdominal aortic surgeries at Hartford Hospital from January 2017 to April 2022. Institutional Review Board approval was granted with minimal risk given retrospective nature of our study (IRB number: HHC-2022-0118).

Patient Records Identification

Adult patients who underwent open abdominal aortic surgeries, including open aortic abdominal aneurysm repair and suprainguinal bypass with open abdominal aortic involvement (i.e., aortobifemoral or aortobiliac bypass) for arterial occlusive disease at Hartford Hospital from January 2017 to April 2022 were identified from prospective quality registry data from the vascular quality initiative (VQI).

Chart review was performed to identify use of concomitant regional block for perioperative analgesia (epidural, single-shot rectus sheath block, continuous rectus sheath block with catheters). Rectus sheath blocks are performed by the regional anesthesia team at completion of surgery before leaving the operating room (OR). Using ultrasound guidance and sterile technique regional single-shot block using a combination of 30 ml of 0.5% ropivacaine plus 30 ml normal saline is performed. This is followed by catheter insertion in the bilateral rectus sheaths with continuous infusion of ropivacaine and repeated daily ropivacaine bolus with rounding from the regional anesthesia team for up to 5 postoperative days. Since adjunctive rectus sheath block (RB) was the main interest, we kept patients who received general anesthesia (GA) only and those received both GA concomitant with RB (GA + RB). As single-shot RB was felt to be of lower strength than continuous catheters by our regional anesthesia team, we performed separate analyses both with and without the inclusion of single-shot patients.

Primary extraction of data from the Vascular Quality Initiative (VQI) database was supplemented with individual chart review in our institutional EMR and fully reviewed for the specific surgical inpatient admission, along with up to 30 days of follow-up encounters as indicated in the Hartford Hospital outpatient chart as well as interactions shared through CareEverywhere®. Variables of interest that are maintained in the VQI include: comorbidities including smoking, hypertension, diabetes mellitus, CAD (coronary artery disease), CHF (congestive heart failure), and COPD (chronic obstructive pulmonary disease); indication for surgery including either open abdominal aneurysm repair or suprainguinal bypass with aortic involvement; procedural urgency including either elective, urgent, or emergent; procedural details including ASA (American Society of Anesthesiologists) classification and time to extubation; postoperative complications including myocardial infarction, stroke,

new dysrhythmia, postoperative CHF, respiratory decline, change of renal function, leg ischemia/emboli, wound complication, return to OR; and total length of inpatient stay. Endpoints collected from the institutional EMR that were not in the VQI database included: use of adjunctive regional block and type of block medication (as indicated in the anesthesia record), intraoperative opioids medication as well as intraoperative and postoperative adjunctive analgesia (as indicated in the anesthesia record, including opioid-based medications before extubation, on emergence, and/or while still intubated and transferred out of the OR), time to first successful inpatient mobility session (as assessed by a physical therapist note), usage of inpatient postoperative oral and parenteral pain medication (as assessed by individual medication records within chart review), pain score at 24 hr postop (as assessed by nursing or physician note), length of nasogastric tube (NGT) duration (as assessed by discontinued order), time to return to bowel function (as assessed by resident or attending note advancing the diet from nil per os (NPO) to clear liquids), opioid prescription at discharge (as assessed in discharge summary), and need for opioid refill following discharge (as assessed by any order after discharge in the internal EMR or through CareEverywhere®). To calculate morphine milligram equivalents (MME) for each parameter of interest, we used the following conversions as indicated in the most recent literature[4] (Supplemental Table 1).

Statistical Analysis

The preliminary analysis explored the underlying distribution of numerical variables for the normality test. Numerical data was presented as means and standard deviations or medians and 25th−75th percentiles depending on if the normality assumption was satisfied. The binomial and categorical variables were depicted with frequencies and percentages. For subgroup comparison, categorical data were compared with Pearson chi-squared tests or Fisher's exact tests when the sample size was small; continuous data that met normality assumption were tested with independent *t*-tests, while the ones that did not meet normality assumption were tested with independent samples Mann−Whitney *U*-tests. *P* values < 0.05 were considered statistically significant. All statistical analyses were performed in IBM SPSS Statistics 24.

RESULTS

One-hundred and six patients were captured in this VQI dataset, of which 55 received GA alone (52%), 39 received adjunctive RB + GA (37%) and 12 patients had GA with adjunctive epidural analgesia (11%) (Fig. 1). After removal of patients with epidural analgesia, there were 94 patients remaining for analysis. Thirty-six patients underwent open aneurysm repair and 58 underwent open aortic surgery for PAD.

A comparison of the demographic data between the 2 groups is presented in Table I. There was no significant difference between groups in terms of age, sex, body mass index (BMI), indication for surgery, American Society of Anesthesiology classification, or preoperative chronic opioid use. There was a lower incidence of elective cases in patients with GA alone versus GA + RB (80% vs. 95%, $P = 0.040$). Of note, there was a temporal difference to the patients receiving GA versus GA + RB within the study period; in 2017, 0/15 patients received RB for OAS while 9/10 patients received RB in 2022 ($P < 0.001$). In addition, the GA only group had 10 patients with retroperitoneal repair (RP) versus no RP patients in the GA + RB group. After removal of 1 RP patient with concomitant epidural analgesia, there were more RP patients in the GA group as compared to the GA + RB group ($P = 0.019$). As this treatment modality has a different postoperative pain burden compared to transperitoneal access, we opted to remove these patients from further analysis.

Among all GA and GA + RB patients, intraoperatively patients with GA + RB had higher rates of intraoperative ketamine, regardless of indication for open aortic surgery (GA: 40% vs. GA + RB: 61.5%, $P = 0.049$) (Table II). In addition, patients with GA + RB were identified to have a higher rate of early extubation, defined as extubation in the operation room or within 12 hr postoperation (GA: 44.4% vs. GA + RB: 84.6%, $P < 0.001$). Within this cohort, patients with GA + RB had lower MME utilization than GA alone, within the first 24 hr after surgery (median MME GA: 67.5 vs. GA + RB: 25.0, $P = 0.002$), and at discharge (median MME GA: 225.0 vs. GA + RB: 142.5, $P = 0.036$). Patients with GA + RB had a higher rate of postoperative ketamine administration (GA: 11.1% vs. GA + RB: 59.0%, $P < 0.001$). Twenty-four-hour postoperative resting pain scores were lower for patients with GA + RB compared to GA alone (mean pain score GA: 5 vs. GA + RB: 2, $P < 0.001$), and postoperative use of a patient-controlled analgesia (PCA) pump was lower in the GA + RB group (GA: 64.4% vs. GA + RB: 17.9%, $P < 0.001$). Of note, patients receiving catheter administered rectus sheath block discontinued services, on average, 3.7 days into

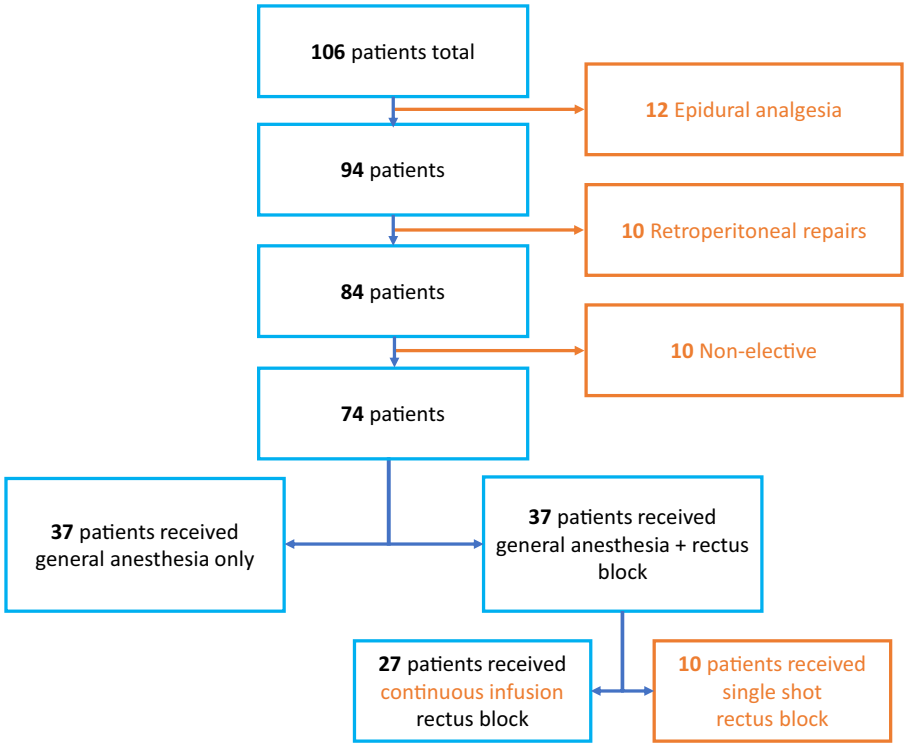

Fig. 1. Flow diagram of patient cohort with subgroups.

their postoperative hospital course. This did not lead to an increase in overall daily MME nor increase utilization of PCA pumps after discontinuation of rectus sheath block (Table II). Other postoperative outcomes were relatively similar between the groups, including the presence of any postoperative complication, time to ambulation, length of NGT duration, return of bowel function, and 30-day readmission rate. Patients with GA + RB did have an overall shorter length of stay (median stay GA: 6 days vs. GA + RB: 5 days, $P = 0.006$).

We performed a subsequent analysis after exclusion of any emergent or symptomatic/urgent patients (Table III). This demonstrated similar findings as to our total cohort, with loss of significance in daily MME consumption beyond the first postoperative day. Our final analysis was to examine the difference between patients with GA versus patients with GA + continuous rectus sheath blocks alone with exclusion of patients with a ''single-shot'' rectus block. This demonstrated overall similar findings to previous, apart from loss of significance in the total discharge MME (150 MME GA + continuous RB vs. 225 MME GA alone, $P = 0.065$) (Table IV).

Due to the increase utilization of ketamine within the GA + RB group, regardless of any exclusion criteria, we decided to perform a sensitivity analysis to identify if utilization of RB was an independent predictor of lower postoperative pain and recovery metrics. As such, we isolated GA ($N = 19$) and GA + continuous RB ($N = 4$) patients who did not receive ketamine throughout their hospital stay, either intraoperatively or postoperatively, and compared their 24-hour postoperative pain scores, discharge MME, and length of stay. Indeed, RB was found to be independently associated with a lower 24-hour resting pain score (GA + RB pain scores ≤ 3, $P = 0.002$), which was not the case for ketamine usage. We also found that continuous RB was an independent predictor of shorter length of stay (≤ 6 days, $P = 0.026$), unlike ketamine usage. However, neither RB nor ketamine usage was independently associated with discharge MME; rather, PCA utilization ($P = 0.016$) and lower 24-hour resting pain scores ($P = 0.035$) was.

DISCUSSION

In this study, we identified that the addition of rectus sheath block to general anesthesia provides improvement in postoperative pain management following open abdominal aortic surgery, including

Table I. Patient Demographics—general anesthesia compared to any rectus sheath block. All procedural urgencies

Demographics	Total ($n = 94$, %)	GA ($n = 55$, %)	GA + RB ($n = 39$, %)	*P*-value
Age at time of procedure (mean ± st dev)	64 ± 9	64 ± 9	63 ± 9	0.461
Male sex	70 (74.5)	44 (80)	26 (66.7)	0.144
BMI, median (CI: 25−75)	26.6 (24.0−30.8)	26.3 (23.3−30.5)	27.2 (24.7−31.2)	0.332
Surgical Class				
Open Abdominal Aneurysm Repair	36 (38.3)	22 (40.0)	14 (35.9)	0.687
Supra-inguinal Bypass	58 (61.7)	33 (60.0)	25 (64.1)	
Comorbidities				
Any tobacco use	92 (97.8)	53 (96.4)	39 (100)	0.508
Hypertension	78 (83.0)	47 (85.5)	31 (79.5)	0.448
Diabetes mellitus	27 (28.7)	16 (29.1)	11 (28.2)	0.925
Coronary artery disease (CAD)	21 (22.3)	12 (21.8)	9 (23.1)	0.885
Congestive heart failure (CHF)	10 (10.6)	8 (14.5)	2 (5.1)	0.145
Chronic obstructive pulmonary disease (COPD)	36 (38.3)	21 (38.2)	15 (38.5)	0.978
ASA Classification (Severe)	35 (37.2)	19 (34.5)	16 (41.0)	0.426
Preoperative chronic opioid use	21 (22.3)	12 (21.8)	9 (23.1)	0.885
Elective procedure	81 (86.2)	**44 (80.0)**	37 (94.9)	**0.040**
Retroperitoneal exposure	8 (9.5)	**8 (14.5)**	0 (0)	**0.019**

Bolded values indicate those that reached statistical significance ($P < 0.05$).
GA, general anesthesia; RB, rectus block; BMI, body mass index; ASA, American society of anesthesiologists; CI, confidence interval.

reductions in 24-hour postoperative MME and discharge MME, and less reliance on PCAs. Patients who did receive rectus sheath block also had better recovery metrics, including shorter length of stay and lower subjective pain scores, further suggesting better overall control of pain relief in this patient population. Nonetheless, the effect that adjunctive rectus sheath block will have on patients with different demographics, patients undergoing other types of open vascular procedures, or patients with poor preoperative pain control remains to be seen. There were other findings in our cohort that suggested maturity of a multimodal pain regimen for OAS, including the intraoperative and postoperative use of ketamine.

Postoperative opioid-based analgesia confers reliable pain reduction but does carry significant risk of tolerance and dependence in postsurgical patients.[1] Specifically, patients with opioids prescribed after hospital discharge have a 44% increase in the risk of long-term opioid use, even if the patient was opioid naïve before the procedure.[5] Risk factors for chronic opioid use and opioid use disorder includes patients who are male, greater than 50 years old, and have a history of alcohol and drug use; many of these demographics are pervasive in vascular surgery patients, making them high risk for development of opioid reliance postsurgery.[5,6] To curb these concerns with opioid usage, some hospital systems have started utilizing enhanced recovery after surgery or in-house electric health record (EMR) alerts for high-quantity opioid prescriptions; a reduction in total prescriptions was seen when EMR setting thresholds were lowered, suggesting that strategies to reduce opioid prescribing could lie within the inpatient EMR itself.[7−9] Specifically for the vascular surgery patient, a VQI retrospective study also identified the need for standardization of opioid prescriptions based on patient factors and procedure type.[10] Even though there is advocacy around less opioid prescription utilization and proper screening of risk factors, many times opioid-based pain relief is unavoidable in vascular surgery patients, given the treatment modality. As such, the utilization of adjunctive analgesics for pain management is even more important in the vascular surgery patient to reduce this exposure and risk of reliance of opioid-based medications.

Aside from rectus sheath blocks, the use of other regional blocks like epidural anesthesia (EA) and spinal anesthesia (SA) have also gained traction in recent years for postoperative pain management. Specifically, SA has been associated with similar postoperative improvements in pain and recovery, with shorter length of ICU stay, as well as decreased postoperative opioid consumption and higher likelihood of no postop opioid use (OR for no use on postoperative day 1 of 214.7 for SA patients).[11] A

Table II. Intraoperative and postoperative outcomes—general anesthesia compared to any rectus block. All procedural urgency without retroperitoneal repair

Procedure metrics	Total ($n = 84$, %)	GA ($n = 45$, %)	GA + RB ($n = 39$, %)	*P*-value
Procedure MME (median, CI: 25—75)	113.0 (85.5—158.1)	130.0 (91.0—168.5)	103.0 (70.0—140.0)	0.137
Procedure ketamine	42 (50.0)	18 (40.0)	**24 (61.5)**	**0.049**
Procedure Time, min (median, CI: 25—75)	282.0 (235.3—372.3)	292.0 (229.0—379.0)	280.0 (236.0—346.0)	0.647
Time to Extubation (in OR or <12 hr post-op)	53 (63.1)	20 (44.4)	**33 (84.6)**	**<0.001**
Postoperative pain management				
0—24 hr postoperative MME (median, CI: 25—75)	44.9 (17.0—96.4)	**67.5 (28.3—149.0)**	25.0 (10.0—70.0)	**0.002**
Postoperative ketamine	28 (33.3)	5 (11.1)	**23 (59.0)**	**<0.001**
Postoperative resting pain score (mean ± standard deviation)	4 (2—5)	**5 (4—6)**	2 (1—3)	**<0.001**
Patient-controlled analgesia pump	36 (42.9)	**29 (64.4)**	7 (17.9)	**<0.001**
Daily MME (24 hr to discharge; median, CI: 25—75)	13.4 (3.1—35.3)	20.0 (5.4—53.7)	12.0 (2.0—20.7)	0.052
Discharge MME (median, CI: 25—75)	160.0 (96.0—240.0)	**225.0 (96.0—336.0)**	142.5 (66.3—212.0)	**0.036**
Additional postoperative outcomes				
Any complications	24 (28.6)	13 (28.9)	11 (28.2)	0.945
Time to ambulation, days (median, CI: 25—75)	3 (2—4)	3 (2—4)	2 (2—4)	0.609
NGT duration, days (median, CI: 25—75)	2 (2—3)	3 (2—3)	2 (1—3)	0.101
Return to bowel function, days (median, CI: 25—75)	3 (3—4)	4 (3—4)	3 (2—4)	0.115
Length of stay, postop to discharge (median, CI: 25—75)	6 (5—7)	**6 (5—9)**	5 (5—7)	**0.006**
30-day readmission[a]	7 (8.6)	4 (9.5)	3 (7.7)	1.000

Bolded values indicate those that reached statistical significance ($P < 0.05$).
GA, general anesthesia; RB, rectus block; MME, morphine milligram equivalents; NGT, nasogastric tube; CI, confidence interval.
[a]Fisher's exact test.

contemporary retrospective analysis of patients undergoing open aortic surgery with EA and general anesthesia (GA), versus GA alone, found that addition of EA was associated with improved 30-day survival (hazard ratio, HR, 0.73) and lower rate of postoperative bowel ischemia, pulmonary complications, or dialysis (OR 0.54, 0.62, and 0.44 respectively).[12] However, a retrospective comparison of SA to ultrasound-guided transversus abdominal plane (TAP) block found no difference in postoperative ambulation, time to feeding, length of stay, and need for postoperative rescue pain medication.[13] This differs from our results with adjunctive rectus sheath block, which identifies a significant decrease in the need for PCA control of postoperative pain along with lower MME utilization and shorter length of stay. In addition, there are significant barriers to use with SA which limit their utilization including contraindication with anticoagulation therapies, hemodynamic changes, patient comfort, and significant complications. Specifically, SA has been shown to increase likelihood of sympathectomy which can lead to hypotension, particularly in patients who are fluid restricted[14]; these side effects do not exist for rectus block. Also, epidural catheters are quite uncomfortable for patients and take separate preoperative time to place on the floors. Rectus sheath blocks, on the other hand, are first established in the OR under sedation, limiting patient discomfort. In addition, depending on the epidural incision site, there could be an opportunity for analgesic to affect the lower extremities and limit mobility, which would increase the patient's risk of deep vein thrombosis and falls. Rectus sheath blocks would not carry these same risky considerations for use.

In further support, rectus sheath blocks have been utilized as adjunctive analgesia in other types of

Table III. Intraoperative and postoperative outcomes—general anesthesia compared to any rectus block. Elective cases only without retroperitoneal repair

Procedure metrics	Total (n = 74, %)	GA (n = 37, %)	GA + RB (n = 37, %)	P-value
Procedure MME (median, CI: 25—75)	115.0 (90.0—160.0)	130.0 (100.0—168.5)	103.0 (70.0—144.0)	0.076
Procedure ketamine	39 (52.7)	15 (40.5)	**24 (64.9)**	**0.036**
Procedure Time, min (median, CI: 25—75)	287.0 (235.8—356.3)	292.0 (229.0—375.5)	282.0 (237.5—348.0)	0.795
Time to Extubation (in OR or <12 hr postop)	49 (66.2)	18 (48.6)	**31 (83.8)**	**0.001**
Postoperative pain management				
0—24 hr post-operative MME (median, CI: 25—75)	38.5 (13.0—80.5)	**55.0 (26.5—120.0)**	24.0 (9.0—74.0)	**0.017**
Postoperative ketamine	27 (36.5)	5 (13.5)	**22 (59.5)**	**<0.001**
Postoperative resting pain score (mean ± standard deviation)	4 (2—5)	**5 (4—6)**	2 (1—3)	**<0.001**
Patient-controlled analgesia pump	34 (45.9)	**28 (75.7)**	6 (16.2)	**<0.001**
Daily MME (24 hr to discharge; median, CI: 25—75)	11.9 (2.4—28.9)	11.8 (2.9—35.3)	12.0 (1.7—21.2)	0.363
Discharge MME (median, CI: 25—75)	160.0 (57.5—240.0)	**225.0 (48.0—336.0)**	131.5 (48.8—208.0)	**0.026**
Additional postoperative outcomes				
Any complications	18 (24.3)	7 (18.9)	11 (29.7)	0.278
Time to ambulation, days (median, CI: 25—75)	3 (2—4)	3 (2—4)	3 (2—4)	0.874
NGT duration, days (median, CI: 25—75)	2 (2—3)	2 (2—3)	2 (1—3)	0.157
Return to bowel function, days (median, CI: 25—75)	3 (3—4)	3 (3—4)	3 (2—4)	0.210
Length of stay, postop to discharge (median, CI: 25—75)	6 (5—7)	**6 (5—9)**	5 (5—7)	**0.004**
30-day readmission[a]	6 (8.1)	3 (8.1)	3 (8.1)	1.000

Bolded values indicate those that reached statistical significance ($P < 0.05$).
GA, general anesthesia; RB, rectus block; MME, morphine milligram equivalents; NGT, nasogastric tube; CI, confidence interval.
[a]Fisher's Exact Test.

open surgeries with similar improvements in postoperative pain control. At our institution, rectus sheath blocks are also being used in conjunction with anterior lumbar interbody fusion procedures, with an almost 25% reduction in opioid utilization at 72 hr postop, significantly lower reported postoperative pain, and 18.7% shorter PACU length of stay.[15] Additionally, a randomized trial on postoperative pain control in splenectomy patients detailed that with combination transversus abdominus block and rectus sheath block, patients were found to have lower pain scores, lower opioid consumption, fewer instances of nausea and emesis and shorter recovery times.[16] Taken together, these results support our enthusiasm for utilization of rectus sheath block in patients who undergo open procedures, and with our study, further advocates for more routine utilization of rectus sheath blocks in more open procedures, including open abdominal aortic repairs.

The utilization of ketamine in this study could have also synergistically conferred pain relief with rectus sheath block. Others have detailed the positive analgesic effect of esketamine during and following other abdominal surgeries like gynecological day surgeries. Specifically, clinicians saw lower rates of 24h postoperative nausea, shorter median length of stay, and fewer adverse side effects in patients who received esketamine in addition to opioid-based regimens.[17] Another study utilized esketamine intraoperatively for thoracic surgeries in an effort to reduce operative and immediately postoperative opioid administration, with an improvement in quality metrics like length of stay.[18] Even more, others have identified that intravenous infusion of ketamine during elective open abdominal surgeries significantly reduced analgesic requirements in the first 24-hour postoperative period.[19] The results of the current study indicate a

Table IV. Intraoperative and postoperative outcomes, general anesthesia versus continuous rectus sheath catheters. Elective cases only without retroperitoneal repair

Procedure metrics	Total ($n = 64$, %)	GA ($n = 37$, %)	GA + RB (continuous infusion) ($n = 27$, %)	P-value
Procedure MME (median, CI: 25−75)	113.0 (90.5−160.0)	130.0 (100.0−168.5)	100.0 (70.0−129.0)	0.055
Procedure ketamine	33 (51.6)	15 (40.5)	**18 (66.7)**	**0.039**
Procedure Time, min (median, CI: 25−75)	287.0 (240.8−375.8)	292.0 (229.0−375.5)	282.0 (255.0−392.0)	0.940
Time to Extubation (in OR or <12 hr postop)	39 (60.9)	18 (48.6)	**21 (77.8)**	**0.018**
Postoperative pain management				
0−24 hr postoperative MME (median, CI: 25−75)	43.0 (14.3−89.6)	55.0 (26.5−120.0)	24.0 (8.0−80.0)	0.055
Postoperative ketamine	24 (37.5)	5 (13.5)	**19 (70.4)**	**<0.001**
Postoperative resting pain score (mean ± standard deviation)	4 (2−5)	**5 (4−6)**	2 (0−3)	**<0.001**
Patient-controlled analgesia pump	30 (46.9)	**28 (75.7)**	2 (7.4)	**<0.001**
Daily MME (24 hr to discharge; median, CI: 25−75)	10.8 (1.7−31.3)	11.8 (2.9−35.3)	9.0 (1.3−17.7)	0.267
Discharge MME (median, CI: 25−75)	160.0 (40.0−288.0)	225.0 (48.0−336.0)	150.0 (30.0−224.3)	0.065
Additional postoperative outcomes				
Any complications	16 (25.0)	7 (18.9)	9 (33.3)	0.188
Time to ambulation, days (median, CI: 25−75)	3 (2−4)	3 (2−4)	3 (2−4)	0.890
NGT duration, days (median, CI: 25−75)	2 (2−3)	2 (2−3)	2 (1−3)	0.072
Return to bowel function, days (median, CI: 25−75)	3 (3−4)	3 (3−4)	3 (2−4)	0.109
Length of stay, postop to discharge (median, CI: 25−75)	6 (5−7)	**6 (5−9)**	5 (4−6)	**0.003**
30-day readmission[a]	6 (9.4)	3 (8.1)	3 (11.1)	0.691

Bolded values indicate those that reached statistical significance ($P < 0.05$).

GA, general anesthesia; RB, rectus block; MME, morphine milligram equivalents; NGT, nasogastric tube; CI, confidence interval.

[a]Fisher's Exact Test.

higher utilization of intraoperative and postoperative ketamine for patients who received GA + RB, with concurrent reductions in pain scores and opioid utilization as discussed in the aforementioned studies. Due to the uneven utilization of ketamine usage between groups, this could have introduced an unbalanced confounding variable, which could skew our results from this study. Even after sensitivity analysis to address this confounder, low remaining participant numbers decreases the statistical power of our results and limit our conclusions. Nonetheless, given that low dose ketamine has a much lower potential for abuse and misuse compared to opioids,[20] we would advocate for adjunctive ketamine usage for postoperative pain management.

Other potential confounding variables in this study include selection of patients who received rectus sheath blocks, surgical intervention during a long hospital stay, and prior surgical interventions. The consideration of selecting a rectus sheath block for a patient at the start of any procedure may introduce selection bias, in that patients who were considered to do well with a rectus block were the only ones offered it, and not every patient who received open abdominal surgery. This is especially the case when considering all open abdominal aortic surgeries are not elective procedures. In addition, there is no specific criterion that the vascular or anesthesia team used to determine if a patient would benefit from adjunctive rectus sheath block preoperatively, which prompted the initiation of this cohort study, to identify an ideal patient population that would maximally benefit from this supplemental intervention.

As with many cohort studies, limitations arise solely by the nature of the data collection preceding the study design. For this study, that would include low quality charting, like the absence of a physical therapy or nursing note indicating a change in the patient's care or medication administration time errors. Along those lines, procedural MME lacked temporal resolution in identifying MME utilization before extubation, on emergence from anesthesia, or even in transit while still intubated. As patients in the GA + RB group had a shorter time to extubation, this should have conferred a statistically significant difference in procedural MME, but did not, further signifying issues in charting these events to compare for quality improvement by this adjunctive therapy. Also, since our study relies on subjective pain scoring for an outcome measure, these results may be difficult to interpret across patients. An additional limitation may arise from a limited patient population to begin with, which will decrease the confidence of our results. Given the above concerns, we may also find missing data points for primary outcome measures in chart review, which may further decrease the number of participants to compare between modalities. Finally, the adoption of novel pain-management therapies such as the rectus sheath catheters do not occur in a vacuum, and some of our results may be affected by multispecialty efforts at enhanced recovery following aortic surgery, as evidenced by increased ketamine use, earlier time to extubation, and the overrepresentation of GA + RB patients in later years of the study (2022 vs. 2017). However, even with our small sample size we saw the objective decreases in postoperative and discharge MME as well as pain score.

CONCLUSION

In conclusion, we have identified that the addition of adjunctive rectus sheath block for patients undergoing open aortic abdominal surgery benefits their postoperative course. Patients who received rectus sheath blocks had overall less utilization of MME, shorter length of stay, lower subjective pain scores, and greater ketamine usage than their general anesthesia counterparts. Given these results, the utilization of rectus sheath blocks as part of the postoperative analgesia plan suggests that patients had a lower perception of postoperative pain, even with less opioid-based analgesics. As such, we encourage the further utilization of this analgesic modality for similar patients who undergo open abdominal vascular surgery procedures.

SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.avsg.2023.04.012.

REFERENCES

1. Clement KC, Canner JK, Sussman MS, et al. Persistent opioid use after open aortic surgery: risk factors, costs, and consequences. Ann Thorac Surg 2021;112:1939–45.
2. Greco KJ, Brovman EY, Nguyen LL, et al. The impact of epidural analgesia on perioperative morbidity or mortality after open abdominal aortic aneurysm repair. Ann Vasc Surg 2020;66:44–53.
3. Guay J, Kopp S. Epidural pain relief versus systemic opioid based pain relief for abdominal aortic surgery. Cochrane Database Syst Rev 2016;2016:CD005059.
4. Rosenquist, R. Use of opioids in the management of chronic non-cancer pain. Post TW, ed. UpToDate. Waltham, MA: UpToDate Inc.
5. Hah JM, Bateman BT, Ratliff J, et al. Chronic opioid use after surgery: implications for perioperative management in

the face of the opioid epidemic. Anesth Analg 2017;125:1733–40.
6. Lawal OD, Gold J, Murthy A, et al. Rate and risk factors associated with prolonged opioid use after surgery: a systematic review and meta-analysis. JAMA Netw Open 2020;3:e207367.
7. Montoy JCC, Coralic Z, Herring AA, et al. Association of default electronic medical record settings with health care professional patterns of opioid prescribing in emergency departments: a randomized quality improvement study. JAMA Intern Med 2020;180:487–93.
8. Smalley CM, Willner MA, Muir MR, et al. Electronic medical record-based interventions to encourage opioid prescribing best practices in the emergency department. Am J Emerg Med 2020;38:1647–51.
9. Levytska K, Yu Z, Wally M, et al. Enhanced recovery after surgery (ERAS) protocol is associated with lower postoperative opioid use and a reduced office burden after minimally invasive surgery. Gynecol Oncol 2022;166:471–5.
10. Gifford ED, Hanson KT, Davila VJ, et al. Patient and institutional factors associated with postoperative opioid prescribing after common vascular procedures. J Vasc Surg 2020;71:1347–1356.e11.
11. Jessula S, Atkinson L, Casey P, et al. Surgically positioned paravertebral catheters and postoperative analgesia after open abdominal aortic aneurysm repair. J Vasc Surg 2019;70:1479–87.
12. Bardia A, Sood A, Mahmood F, et al. Combined epidural-general anesthesia vs general anesthesia alone for elective abdominal aortic aneurysm repair. JAMA Surg 2016;151:1116–23.
13. Minami E, Kawashima S, Kato T, et al. [Analgesic efficacy of transversus abdominis plane block after open abdominal aortic aneurysm surgery]. Masui 2014;63:1089–92.
14. Parnass SM, Schmidt KJ. Adverse effects of spinal and epidural anaesthesia. Drug Saf 1990;5:179–94.
15. Esmende SM, Solomito MJ, Eisler J, et al. Utility of the transversus abdominis plane and rectus sheath blocks in patients undergoing anterior lumbar interbody fusions. Spine J 2022;22:1660–5.
16. Zhu JL, Wang XT, Gong J, et al. The combination of transversus abdominis plane block and rectus sheath block reduced postoperative pain after splenectomy: a randomized trial. BMC Anesthesiol 2020;20:22.
17. Zhu T, Zhao X, Sun M, et al. Opioid-reduced anesthesia based on esketamine in gynecological day surgery: a randomized double-blind controlled study. BMC Anesthesiol 2022;22:354.
18. Yuan J, Chen S, Xie Y, et al. Intraoperative intravenous infusion of esmketamine has opioid-sparing effect and Improves the quality of recovery in patients undergoing thoracic surgery: a randomized, double-blind, placebo-controlled clinical trial. Pain Physician 2022;25:E1389–97.
19. Imani F, Bagheri AR, Arvin E, et al. Effects of ketamine and lidocaine infusion on acute pain after elective open abdominal surgery, a randomized, double-blinded study. Med J Islam Repub Iran 2022;36:60.
20. Radvansky BM, Shah K, Parikh A, et al. Role of ketamine in acute postoperative pain management: a narrative review. Biomed Res Int 2015;2015:749837.