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Article

Transversus Abdominis Plane with Rectus Sheath Blocks versus Port Site Infiltration of Local Anaesthesia in Emergency Laparoscopic Cholecystectomy. Does It Reduce Postoperative Opiate Requirement? A Pilot Study

Sara Izwan [1,2], Tanishk Malhotra [1,3], Ujvala Vemuru [1,3] and Michelle Cooper [1,*]

[1] Department of General Surgery, Gold Coast University Hospital, Southport, Queensland, Australia
[2] School of Medicine and Dentistry, Griffith University, Southport, Queensland, Australia
[3] Faculty of Health Sciences and Medicine, Bond University, Robina, Queensland, Australia
* Correspondence: michelle.cooper2@health.qld.gov.au

Abstract: Laparoscopic cholecystectomy (LC) is the gold standard of treatment for symptomatic gallstone disease. The aim of this study is to determine if postoperative opiate use is reduced with transversus abdominus plane (TAP) and rectus sheath (RS) regional anaesthetic blocks compared to port site local anaesthetic (LA) infiltration. A prospective, randomised cohort study was conducted of adult patients who underwent an emergency LC between 25 April 2022 and 25 May 2023. 40mls of 0.375% ropivacaine was infiltrated as either TAP and RS blocks or to port sites. Patient demographics, operative data and postoperative opioid use were collected from the medical record. 138 patients were enrolled in this study; 73 patients allocated to the LA to port sites cohort (52.9%) and 65 patients in the TAP and RS cohort (43.5%). The most common indication for surgery was acute cholecystitis. The average amount of opiate analgesia use was 115.2mg in the LA group compared to 61.2mg in the TAP and RS group (p<0.05). Optimisation of postoperative pain allows for early recovery, improved patient satisfaction, and improved cost-effectiveness for the health service. With a trend towards multimodal analgesia, the uptake of TAP and RS regional anaesthesia may help to achieve this goal.

Keywords: laparoscopic cholecystectomy; regional anaesthesia; general surgery

1. Introduction

1.1. Laparoscopic Cholecystectomy

Emergency laparoscopic cholecystectomy (LC) is a common surgical procedure [1]. The Acute Surgical Unit (ASU) performs approximately 20 LCs per month between Monday to Friday, as the primary treatment for symptomatic gallstone disease. Though the LC is minimally-invasive surgery, postoperative pain and nausea is the main symptom experienced by patients. Therefore, early management of postoperative symptoms is important as this can optimise quality of life, reduce hospital length of stay, improve clinical outcomes and patient satisfaction, and reduce the burden of cost on the health service [2].

Opioid analgesia is associated with side effects of nausea, vomiting, constipation, ileus, and urinary retention [3]. The concept of enhanced recovery after surgery (ERAS) programs have led to increased awareness and uptake of multimodal analgesia such as local anaesthetic or regional blocks, with the aim of reducing the amount of postoperative enteral opiate analgesia requirements. This has led to an increasing interest in introducing transversus abdominus plane (TAP) and rectus sheath (RS) regional anaesthetic blocks to add to the multimodal postoperative analgesia regime. Comparatively, intraoperative local anaesthetic (LA) to laparoscopic port sites has been widely used

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to augment postoperative opiate analgesia use by reducing pain locally associated with the incision sites. There are two aspects in which there is significant paucity of data relevant to our study; firstly, the literature to date describes TAP blocks usually performed by the anaesthetist under ultrasound guidance, as opposed to being performed laparoscopically during the LC. Secondly, there is a paucity of data comparing outcomes from TAP and RS regional blocks compared to direct infiltration of LA to port sites.

1.2. TAP and RS Blocks

The TAP block was first described by Rafi in 2001, by using a landmark-based approach through the triangle of Petit [4], and was predominantly performed by anaesthetists under ultrasound guidance. It involves delivery of regional anaesthesia to thoracolumbar nerves originating from T6-T12 and L1 spinal roots. A local anaesthetic agent is infiltrated in the fascial plane between the transverses abdominus and internal oblique muscles (Figure 1) [5]. The propagation of LA in this plane blocks neurological afferents and provides analgesia to the anterolateral abdominal cavity. Ultrasound-guided techniques have traditionally been used to improve accuracy, safety and ease of administration however can significantly extend operative time. Infiltration of TAP blocks laparoscopically has the advantage of efficiency, as delivery can be completed in as little as 30 seconds [6], and identification and confirmation of the correct plane of infiltration is visualised under vision (Doyle's bulge) (Figure 2). The goal of the TAP block is to provide analgesia to skin, muscles and parietal peritoneum.

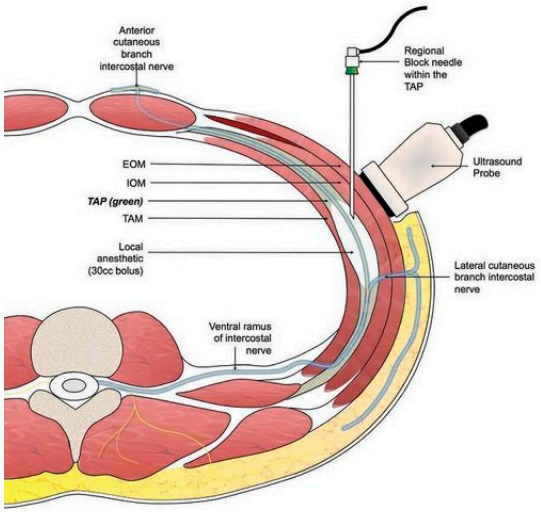

Figure 1. Schematic diagram of intraoperative TAP blockade under ultrasound guidance. The block is infiltrated into the TAP plane midway between the costal margin and iliac crest. (Adapted from Vincent et al.).

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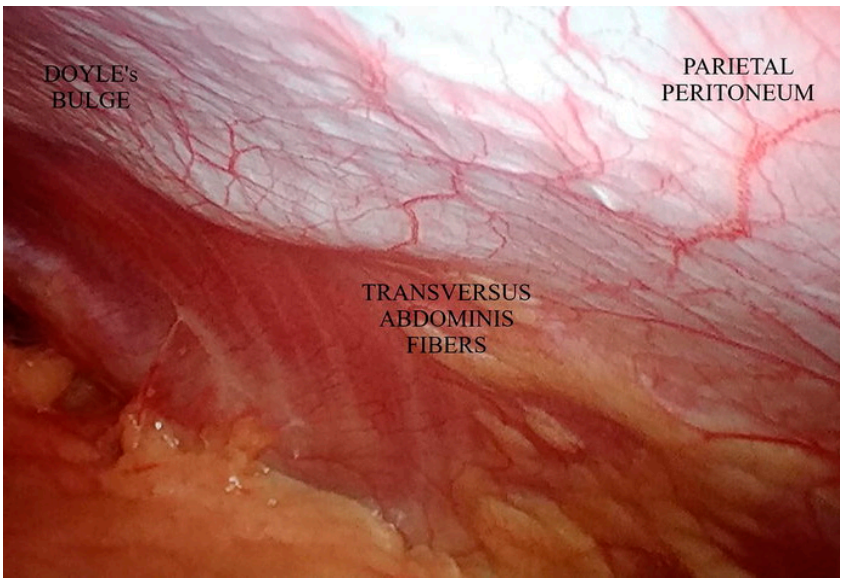

Figure 2. Laparoscopic view of Doyle's bulge, demonstrating infiltration of local anaesthetic into the plane between transversus abdominus and internal oblique. (Adapted from Vindal et al., republished with permission).

However, the literature has suggested that postoperative pain experienced by patients can be attributed to visceral pain which is more pronounced after the LC. Although the TAP block is effective in blocking T6-T9 intercostal nerves, this often does not provide adequate coverage for the umbilical port, which is the extraction port for the gallbladder and the main major source of pain [7]. Therefore, the addition of the RS block to the posterior rectus sheath is a useful adjunct in blocking spinal dermatomes 9, 10 and 11, providing analgesic coverage to the periumbilical area. The RS block is placed at the same time the TAP block is administered, under direct vision along the rectus plane. When used in combination, it is hypothesised that the TAP and RS blocks provide superior analgesic coverage for visceral pain sensation over the anterior abdominal wall at the incision site(s) and area of maximum pain sensation.

1.3. Choice of Local Anaesthetic for Infiltration

A systematic review and meta-analysis by Alsharari et al. compared four different local anaesthetics (bupicaine, ropivacaine, lidocaine and levobupivacaine) of varying concentrations in the use of LC [8]. It was important to consider potential adverse effects of administration of TAP and RS blocks. In particular, laparoscopic placement of TAP and RS blocks was hypothesised to reduce the risk of visceral injury, haematomas, incorrect placement, and local toxicity. A meta-analysis and systematic review demonstrated that TAP blocks provided superior postoperative analgesia for up to 24 hours when compared to port site wound infiltration of local anaesthetic used alone. It is important to note that for most straightforward LCs, patients can be discharged on the day of surgery. Therefore, a significant reduction in use or need for strong opioid analgesia would facilitate early discharge home and reduce costs and the burden to the health service.

1.4. Aims

The primary aim of this study is to determine if postoperative opiate use is reduced with TAP and RS blocks after LC compared to port site LA infiltration alone. Secondary aims are to determine if patient satisfaction is increased with TAP and RS blocks, and if complications related to opiate use are reduced in the TAP and RS blocks cohort compared to the LA to port sites alone group.

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2. Methods

2.1. Study Design and Methodology

A prospective, randomised, single blinded, single-centre cohort study was conducted of adult patients who underwent an emergency LC between 25 April 2022 and 25 May 2023. Patients were allocated to the TAP and RS block cohort or the LA to port sites cohort at the time of the emergency LC. A standard LC set up was consistently used for all patients, positioned in supine with both arms out, and four working ports. An umbilical entry (supra-, infra- or transumbilical) allowed a 12mm Hasson entry. The choice of entry was determined by body habitus and presence of an umbilical hernia.

TAP and RS blocks were performed by a single surgeon. 20mls of 0.75% ropivacaine was diluted with 20mls of 0.9% sodium chloride (to a total of 40mls volume of 0.375% concentration). TAP and RS blocks were infiltrated between the transversus abdominus and internal oblique planes after the camera port was inserted, whereas LA alone was infiltrated in the subcutaneous tissue of the port site entries at the end of the procedure. The total concentration of LA used was the same in both groups.

2.2. Inclusion and Exclusion Criteria

Inclusion criteria were patients over 18 years of age who presented through the emergency department and underwent an emergency LC. Exclusion criteria were patients under 18 years old, pregnant patients, patients that declined inclusion into the study, patients who were unable to provide consent for themselves, patients with documented hypersensitivity to LA, and any laparoscopic converted to open cholecystectomies.

2.3. Data Collection

Patient demographics from the electronic medical record included patient age, sex, body mass index (BMI), diabetes status, smoking status, history of ischaemic heart disease (IHD), immunosuppression or steroid use, or pre-existing long-term analgesia use, and American Society of Anaesthesiologists (ASA) status. Operative data was collected from the perioperative record including type of umbilical entry, drain insertion, subtotal LC, and time of surgery. Postoperative length of stay, cumulative dose of opiate use, length of hospital stay, analgesia requirement in the post anaesthesia care unit (PACU), ward, and throughout their discharge period, by follow up at two weeks post-discharge review in the surgical outpatients department. Data was stored on a secure and encrypted password-protected drive.

2.4. Data Analysis

Data was analysed with the aim of statistical significance for the presence of reduced opiate analgesia requirement post LC and improved patient satisfaction with pain scores. To consistently compare opiate analgesia use across the two cohorts, equianalgesic dosing was calculated for oxycodone, fentanyl, tramadol, tapentadol and codeine use via conversion to their morphine equivalent(s) using the Opioid Calculator app (Faculty of Pain Medicine, ANZCA, Version 3.1.2, 2023). Statistical analysis was performed using SPSS Version 12.1.0 and Microsoft Excel Version 7.3. A p value of <0.05 was used as a marker of statistical significance.

Ethics approval was obtained through the GCHHS human and research ethics committee (HREC). Written informed consent was obtained from all patients for enrolment in this study.

3. Results

3.1. Patient Demographics

A total of 138 patients were enrolled in this study; with 73 patients allocated to the LA to port sites cohort (52.9%) and 65 patients in the TAP and RS cohort (43.5%). Overall, there were 57 male patients (41.3%) compared to 81 female patients (58.7%), consistent with a male-to-female ratio of 5:7. The average BMI of the cohort was 31.1, and median ASA 2. Overall, 23 patients (16.7%) were current smokers, six vaped (4.3%), nine patients had IHD (10.1%), five patients had concurrent steroid use

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(3.62%), and 14 patients (10.1%) had a history of long-term analgesia use. Patient demographics are demonstrated in Table 1.

Table 1. Patient demographics.

	LA to port sites *n*=73 (52.9%)	**TAP and RS** *n*=65 (43.5%)
Age *(years)*		
Median	44	47
Range	20–93	24–80
Average BMI	30.4	31.9
Average ASA	2	2
Smoking status		
Current smoker	12 (16.4%)	12 (18.5%)
Ex-smoker	10 (13.6%)	9 (13.8%)
Non-smoker	51 (69.7%)	44 (67.7%)
IHD	3 (4.1%)	6 (9.2%)
Immunosuppression/steroid use	4 (5.5%)	1 (1.5%)
Long-term analgesia use	9 (12.3%)	5 (7.7%)
Diabetes status		
Diabetic	5 (6.8%)	9 (13.8%)
Non-diabetic	68 (93.2%)	56 (86.2%)

LA: Local anaesthetic; **TAP**: transversus abdominus plane; **RS**: rectus sheath; **BMI**: body mass index. **ASA** = American Society of Anaesthesiologists physical status classification system; **IHD**: ischaemic heart disease.

3.2. Operative Data

The most common indication for an emergency LC was acute cholecystitis (n=92, 66.7%), followed by symptomatic recurrent biliary colic (n=20, 14.5%), and the least common indication was cholangitis, with one patient (0.72%) undergoing an LC. Figure 3 demonstrates all indications for surgery. An infraumbilical 12mm port entry was the most common approach used (n=90, 65.2%), two patients had a 5mm optical entry due to prior surgery (1.4%), and one had an open cutdown to the right paramedian also due to prior surgery (0.72%). The average time from ED presentation to theatre (surgical start time) was 46 hours (1.9 days). These patients were triaged as "Category C" on the emergency board to be completed within 24 hours. Average postoperative length of stay (LOS) in the LA group was 1.26 days, compared to LOS in the TAP/RS group of 1.08 days (p=0.11). Ten patients in the LA cohort raised concerns at the time of their postoperative phone call regarding postoperative wound issues, compared to four patients in the TAP/RS cohort. Of the whole cohort, 18 patients (13.0%) were lost to follow-up. Operative data within each cohort are demonstrated in Table 2.

Table 2. Operative data. There was no statistically significant difference in average OT time or postoperative LOS between each cohort.

	LA to port sites *n*=73 (52.9%)	**TAP/RS** *n*=65 (43.5%)
Entry technique		
Infraumbilical	52 (71.2%)	38 (58.5%)
Transumbilical	7 (9.6%)	16 (24.6%)
Supraumbilical	10 (13.7%)	11 (16.9%)
Optical	2 (2.7%)	0

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Open cutdown to right paramedian	1 (1.4%)	0
Unknown (not documented)	1 (1.4%)	0
Average OT time *(hours)*	1.40	1.47
Average postoperative LOS *(days)*	1.26	1.08
Drain	14 (19.2%)	10 (15.4%)
Subtotal LC	4 (5.5%)	4 (6.2%)
OT time *(min)*	100.6	97.8
Postoperative wound concerns	11 (15.1%)	4 (6.2%)

LA: Local anaesthetic; **TAP**: transversus abdominus plane; **RS**: rectus sheath; **OT**: operating theatre; **LOS**: length of stay; **LC**: laparoscopic cholecystectomy; **OT**: operating theatre

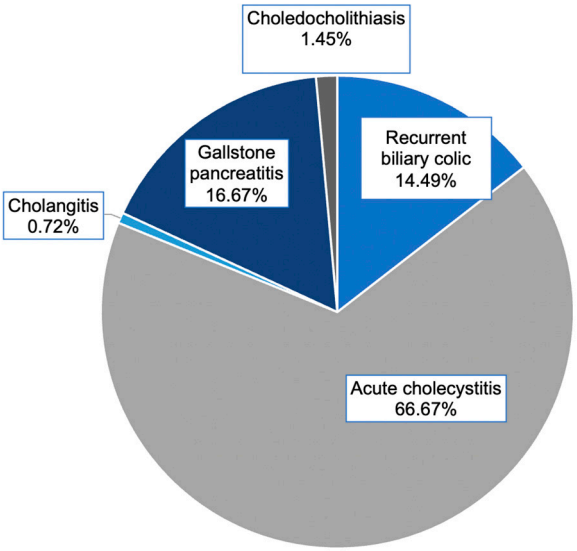

Figure 3. Indications for emergency LC.

3.3. Postoperative Opiate Analgesia use

Figure 4 demonstrates the average amounts of opiate analgesia use in PACU, on the ward, at the time of the postoperative phone call in clinic, and overall (total) opiate analgesia use.

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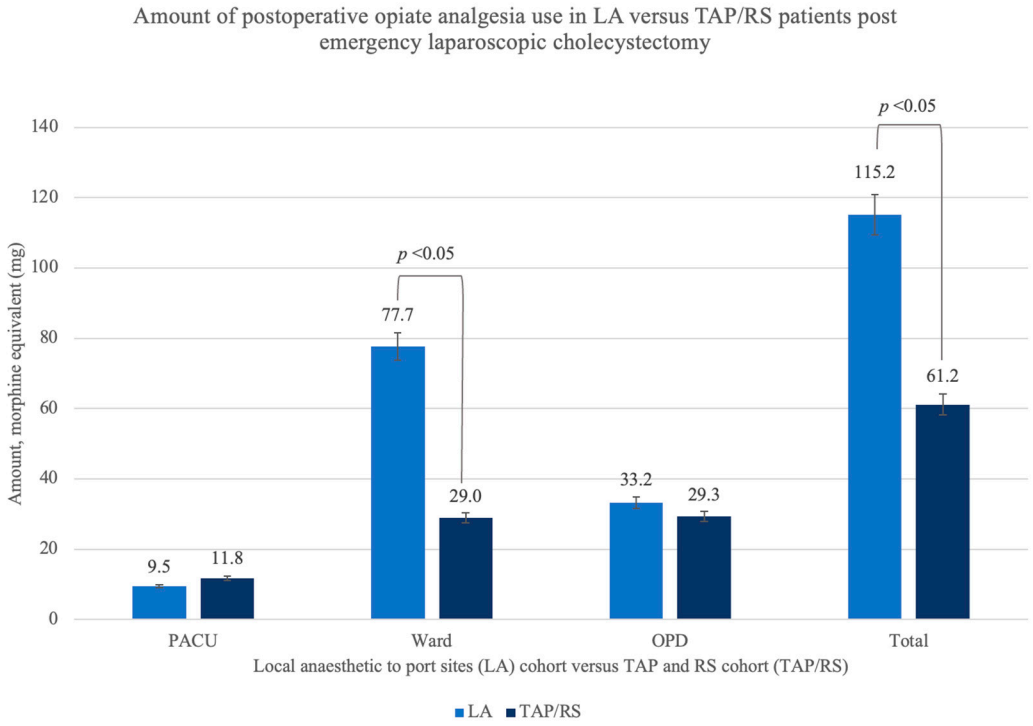

Figure 4. The amount of postoperative opiate analgesia use (morphine equivalent) in LA versus TAP and RS patients post emergency laparoscopic cholecystectomy. There was a statistically significant reduction in amount of postoperative opiate analgesia use on the ward, and in total, in TAP and RS patients compared to the LA cohort (p<0.05).

3.3.1. PACU Results

The average amount of time spent in PACU for the LA group was 71 minutes, compared to the TAP and RS group of 76 minutes. The average of total opiate analgesia used in PACU was 9.5mg (morphine equivalent) in the LA group, compared to 11.8mg (morphine equivalent) in the TAP and RS group (p=0.28). The time to rescue opiate in the LA group was 76.5 minutes, compared to 102.3 minutes in the TAP and RS group.

3.3.2. Ward Results

There was less opiate analgesia use in patients on the ward who had received a TAP and RS block, with an average of 29mg (morphine equivalent), compared to 77.7mg (morphine equivalent) in the LA group, however this difference was not statistically significant (p=0.13).

3.3.3. Outpatient Department (OPD) Results

There was no significant difference between the average amount of opiate analgesia (morphine equivalent) used in the LA group of 33.2mg, compared to the TAP and RS group of 29.3mg (p=0.32) at the time of the OPD follow-up phone call.

3.3.4. Total Results

There was significantly less use of opiate analgesia in the TAP and RS groups compared to LA to port sites, with the average amount of opiate analgesia (morphine equivalent) used in the LA group of 115.2mg compared to the TAP and RS group of 61.2mg (p<0.05).

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4. Discussion

Symptomatic gallstone disease is one of the most common ED presentations, to which emergency LC is the gold standard treatment. TAP blocks have consistently shown to provide superior pain relief compared to wound infiltration, with reduced pain scores at various time points and during movement. Additionally, TAP blocks have been associated with lower opioid consumption and fewer instances of postoperative nausea and vomiting, indicating a potential for improved patient outcomes. Therefore, the optimisation of these patient outcomes, particularly postoperative pain and opiate analgesia requirements, allows for early recovery, improved patient satisfaction, and improved cost-effectiveness for the health service. With the advent of ERAS and a trend towards multimodal analgesia, the uptake of TAP and RS regional anaesthesia may help to achieve this goal.

4.1. Local Anaesthetic

Surgical incision results in an activation of nociceptors found in skin, muscle, and viscera. Stimulation of nociceptors causes depolarisation which activates voltage-gated sodium channels [9]. Ropivacaine is a long-acting regional anaesthetic which causes reversible inhibition of sodium ion influx, and subsequently blocking impulse conduction in nerve fibres. Given its reduced lipophilic properties it is less likely to penetrate large myelinated motor fibres, and has selective action on pain-transmitting A, B and C nerve conduction pathways [10]. It is the anaesthetic agent of choice in epidurals for postoperative or commonly, labour control [11].

As a structural amide, it has moderate onset and an elimination half-life of 120 minutes [9]. There are many studies that have compared the efficacy of local anaesthetics (bupivacaine, levobupicavaine, and lidocaine) and ropivacaine was chosen as the local anaesthetic choice in this study due to its superior effectiveness [8,12]. Ropivacaine is generally well-tolerated, and a pooled analysis from controlled clinical trials of patients receiving ropivacaine concentrations from 0.125 to 1% for nerve blocks indicated that common adverse reactions included hypotension (32%), nausea or vomiting (7-17%), bradycardia (6%) and headache (7%) [11]. None of these side effects were specifically recorded in our study.

4.2. Delivery of the Regional Block

Accuracy and efficiency of delivery of the TAP block is improved laparoscopically compared to under ultrasound-guidance. A randomised controlled trial by Siriwardana et al. demonstrated LA was only delivered correctly 23% of the time, with 18% of cases delivered intraperitoneally [13]. A meta-analysis by Hamid et al. indicated that a RS block provides the greatest pain relief in the first two hours postoperatively, and a reduction in 24-hour morphine equivalent consumption compared to port site infiltration of LA [14]. However, this difference is no longer significant after the first 24 hours, with the reason suggested as RS blocking only the anterior rami of ventral branches of the spinal nerves, but not sufficient to address the visceral pain experienced from the port site incisions in the anterior abdominal wall.

4.3. Postoperative Pain Relief

A study by Grape et al. reported improved patient outcomes in the TAP/RS cohort compared to the wound infiltration/LA cohort [15]. The results of our study demonstrate no significant difference between the amount of time spent in PACU postoperatively either in the TAP and RS group or the LA group. Interestingly, the time to rescue opiate in the LA group was 76.5 minutes, compared to 102.3 minutes in the TAP and RS group, however the average amount of opiate analgesia used in PACU was 9.5mg (morphine equivalent) in the LA group, compared to 11.8mg (morphine equivalent) in the TAP and RS group. Although this difference was not statistically significant, it is hypothesised that this is related to the delayed effects of the regional blocks on anaesthetising spinal nerves, therefore comparatively appears that more opiate analgesia is required in PACU in the TAP and RS group.

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There was significantly less overall opiate analgesia use in patients who had received a TAP and RS block, with an average of 61.2mg (morphine equivalent), compared to 115.2mg (morphine equivalent) in the LA group (p<0.05). Interestingly, although the outcomes for opiate use in PACU, and on discharge from the ward were similar, there was significantly less opiate analgesia use in patients on the ward who received a TAP and RS block, compared to the LA group. This may be due to a number of factors, some which include patient demographics (results were not controlled for opiate naivety versus opiate tolerant patients) and the fact that analgesia administered in PACU or the ward are PRN dosages, whereas on discharge patients are able to self-administer from their own supply once provided a discharge script. It is important to also note patients' ability to accurately recall amount of opiate analgesia use on discharge. To mitigate this issue, further studies have introduced a standardised template to be used by all patients to allow them to record the amount of postoperative analgesia used.

4.4. Limitations

This study was set up as a pilot study and so is limited by its small sample size. Although patient factors such as preoperative long-term analgesia use, smoking status, diabetes and immunocompromise were collected and identified, further subgroup analyses were not performed into the effect of these positive results on opiate analgesic requirement. For example, patient factors such as opiate naivety versus opiate tolerance, the use of other analgesics or long-term lyrica or pregabalin, BMI (a standardised concentration of 0.375% ropivacaine in a total of 40mls in volume of solution was used for all patients, as opposed to a strict mg/kg dosage), previous surgery or degree of difficulty of procedure.

The amount of opiate analgesia used in PACU was meant to be representative of the postoperative opiate requirements in the first 6 hours, compared to the ward (12 hours) and at the time of the clinic appointment post-discharge (>24 hours), however these times are used as estimates.

There were 14 patients overall with a documented history of long-term analgesia use, but there was no disproportion of patients who required significantly higher amounts of opiate analgesia (in either group), however this may be attributed to the study's small sample size, as it is well known that perioperative pain management for opioid-tolerant patients can be challenging, given the complex neurobiological interplay between opioid tolerance and opioid-induced hyperalgesia. The total amount of opiate analgesia use was not averaged over a specific timeframe, therefore there may also have appeared to be a disconcordant use of opiate analgesia in patients who, for example, remained an inpatient for two days compared to a patient discharged on Day 0 of surgery.

Data was not standardised with regards to intraoperative analgesia provided by the anaesthetic team including use of ketamine, ibuprofen or parecoxib, or antiemetics, for example, droperidol. Further research should identify if there is a role for streamlining an intraoperative anaesthetic analgesic regime. Similarly, data was not standardised with regards to dosing of opiates; future studies should look at all patients being prescribed the same regime of pro re nata (PRN) "as required" medications including oxycodone, fentanyl, tramadol, and so on. Similarly, regular versus PRN paracetamol and ibuprofen may have also affected the total amount provided to patients within their given timeframe. Lastly, a study by Aldohayan demonstrated that intraoperative pre-incisional laparoscopic preperitoneal local anaesthetic infiltration was significantly associated with reduced pain scores in the PACU [16]. This differs from our study in which LA was placed at port sites at the end of the case, prior to skin closure.

4.5. Future Studies

The results of this pilot study are currently being used to guide a larger cohort study., which has expanded with the addition of two other consultants within the ASU. Consistent data collection with the use of templates for both patients (self-recording of opiate analgesia usage) and for the ASU team to collate this data, will allow more accurate documentation for data analysis.

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5. Conclusions

The use of TAP and RS blocks has demonstrated a reduction in the use of postoperative opiate analgesia in the emergency LC. Early results are promising and are currently being used to guide a larger cohort study in order to determine the significance of these results. These results should guide implementation of a standardised protocol that encourages TAP and RS blocks compared to conventional infiltration of LA to port sites, as this not only reduces the amount of opiates required, but is also simple and efficient to perform, and cost effective for the health service. In addition, the administration of TAP and RS blocks adds little to the surgical operative time, is administered under vision with direct visualisation, as opposed to being infiltrated separately by the Anaesthetics team and has already shown encouraging results as demonstrated in this study.

Author Contributions: Conceptualisation, SI and MC; methodology, SI and MC; formal analysis, SI, TM, UV; investigation, SI; resources, SI and MC; data curation, SI and MC; writing—original draft preparation, SI, TM, UV; writing—review and editing, SI and MC; visualisation, MC; supervision, MC; project administration, SI; funding acquisition, Nil. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: Ethics approval was obtained through the GCHHS human and research ethics committee, reference HREC/2021/QGC/78002.

Informed Consent Statement: Written informed consent was obtained from all patients for enrolment in this study and for publication in this paper.

Data Availability Statement: Due to privacy reasons, the datasets presented in this study are available on request from the corresponding author due to the raw data consisting of identifying patient hospital Unique Record Number (URN) and date of birth (DOB).

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Conflicts of Interest: The authors declare no conflicts of interest.

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