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ORIGINAL CONTRIBUTIONS

Laparoscopic-Guided Transversus Abdominis Plane (TAP) Block as Part of Multimodal Analgesia in Laparoscopic Roux-en-Y Gastric Bypass Within an Enhanced Recovery After Surgery (ERAS) Program: a Prospective Randomized Clinical Trial

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Abstract

Background Despite the ultrasound guidance of transversus abdominis plane (TAP) blocks has allowed greater precision of needle placement in the desired tissue plane, visualization of the abdominal wall muscles can be hindered by morbid obesity and could lead to failed regional anesthesia. The aim of this study was to assess the feasibility and effect of laparoscopic-guided TAP block in patients undergoing Roux-en-Y gastric bypass and to compare it with port-site infiltration.

Patients and Methods A prospective randomized clinical trial was performed. Patients were randomized into two groups: patients undergoing laparoscopic-guided TAP (TAP-lap) and patients undergoing port-site infiltration (PSI). Pain quantification as measured by visual analogic scale (VAS) and morphine needs during the first 24 h were evaluated.

Results One hundred and forty patients were included, 70 in each group. The mean operation time was 83.3 + 15.6 min in TAP-lap and 80.5 + 14.4 min in PSI (NS). The mean postoperative pain, as measured by VAS, 24 h after surgery was 16.8 + 11.2 mm in PSI and 10 + 8.1 mm in TAP-lap ($p = 0.001$). Morphine rescues were necessary in 13.2% in PSI and 2.9% in TAP-lap ($p = 0.026$). The mean hospital stay was 2.1 + 1.2 days in TAP-lap and 2.9 + 1.3 days in PSI ($p = 0.019$). Hospital discharge during the first 48 h after surgery was possible in 52.9% of the patients in PSI and 71% in TAP-lap (OR 4.75; 95% CI 2.1–10.8; $p = 0.029$).

Conclusion Laparoscopic-guided TAP block can reduce postoperative pain, opioid needs, and hospital stay, when compared with port-site infiltration with the same anesthetic drug, without increasing operation time.

Trial Registration ClinicalTrials.gov Identifier: NCT03203070

Keywords Transversus abdominis plane block · Laparoscopy · Roux-en-Y gastric bypass · Postoperative pain

Introduction

Bariatric surgery has been shown to be effective in achieving and maintaining weight loss and reducing obesity-related comorbidities [1, 2]. Bariatric surgery is mostly performed laparoscopically. It has been demonstrated that the laparoscopic approach is associated with lower complications rates, shorter hospital stay, and earlier reincorporation to normal activities, than open procedures [3]. However, the adequate management of postoperative pain remains a major challenge, as it might condition the appearance of major morbidity, mainly pulmonary complications, leading to a decrease in the health-related quality of life in the immediate postsurgical period [4].

Therefore, in an effort to reduce the incidence and severity of postoperative pain, multimodal analgesia, as part of Enhanced Recovery After Surgery (ERAS) programs, has been defended by many authors. Multimodal analgesia involves the use of two or more drugs with different mechanisms

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of action in an effort to maximize analgesic efficacy, while reducing the risk and severity of adverse events [5]. These protocols applied to laparoscopic bariatric surgery mostly include the association of intravenous analgesia with the port-site infiltration with local anesthetic drugs [6]. A previous study of our group demonstrated that port-site infiltration with bupivacaine associated with intravenous analgesia achieves a significantly better pain control than intravenous analgesia alone [7].

The transversus abdominis plane (TAP) block is a regional anesthetic technique that targets the sensory nerve supply of the anterior-lateral abdominal wall. The block is performed by injecting local anesthetic into the plane between the internal oblique and the transversus abdominis muscles using the triangle of Petit as a landmark. This TAP plane is infiltrated with local anesthetics to target the T7–T12 intercostal nerves and the ilioinguinal, iliohypogastric, and the lateral cutaneous branches of the dorsal rami of L1–L3 [8, 9].

TAP blocks have been successfully implemented for pain control after laparoscopic surgery in non-obese patients undergoing diverse procedures [10]. The resulting analgesia may be especially beneficial in morbidly obese patients after abdominal surgery due to their higher risk for postoperative pulmonary complications [11, 12]. The introduction of ultrasound guidance has allowed greater precision of needle placement in the desired tissue plane [13]. However, visualization of the abdominal wall muscles can be hindered by morbid obesity and could lead to failed regional anesthesia [14].

We undertook this study to determine the feasibility of using laparoscopic-guided TAP blocks in patients with morbid obesity undergoing Roux-en-Y gastric bypass (RYGB) and compare its analgesic effect postoperatively with the classical method of port-site infiltration.

Patients and Methods

A prospective randomized clinical trial of patients undergoing RYGB at a single institution was performed between March and December 2017. Inclusion criteria were body mass index (BMI) > 40 kg/m^2 or BMI > 35 kg/m^2 with the presence of comorbidities associated to obesity. Exclusion criteria were patients undergoing other bariatric techniques, severe underlying cardiovascular diseases, chronic renal failure, hepatic dysfunction, and previous foregut surgery and patients with any contraindication for bariatric surgery. Patients presenting postoperative complications were excluded from the final analysis.

The sample size calculation was based on historic data of our center of postoperative pain quantification by visual analogic scale (VAS) 24 h after surgery in patients undergoing port-site infiltration with bupivacaine 0.5% associated with intravenous analgesia (control group—40 mm) and an expected reduction to 20 mm in patients undergoing the combination of intravenous analgesia with laparoscopic-guided TAP block with bupivacaine (experimental group). At 80% power and a significance level of $p = 0.05$, it was calculated that 63 patients were required in each arm of the study. Assuming an eventual complications rate of 10%, the sample size was increased up to 70 patients in each arm of study.

Patients were randomized using a computerized simple randomization scheme in a 1:1 ratio into two groups: those patients undergoing laparoscopic-guided TAP associated to intravenous analgesia (TAP-lap group) and those ones receiving intravenous analgesia associated with port-site infiltration (PSI group).

Preoperative Evaluation

A multidisciplinary team, including surgeons, endocrinologists, anesthesiologists, and psychiatrists, performed a combined medical, nutritional, and endocrinological work-up to evaluate potential surgical candidates. Preoperative assessment included abdominal ultrasound, upper gastrointestinal endoscopy, polysomnography, and analytical evaluation of the nutritional status.

Surgical Technique

Five ports were placed in right hypochondrium (12 mm), left hypochondrium (12 mm), epigastrium (11 mm), and subxyphoideal (11 mm) and left flank (5 mm). Pneumoperitoneum pressure was established in 12 mmHg. A 6-cm long gastric pouch was performed, calibrating it with a 36-Fr bougie, with a linear stapler (Echelon Flex, Johnson&Johnson, USA). A 60-cm biliary limb and a 150-cm alimentary limb were performed. Both anastomoses were performed with linear stapler (Echelon Flex, Johnson&Johnson, USA), calibrating the gastrojejunal anastomosis at 2 cm. Mesenteric defects were not closed in any of the cases. The integrity of the anastomoses and staple lines were checked with intraoperative methylene blue dye; postoperative tests were not used.

Analgesic Technique

Intravenous analgesia included metamizole 2 g/8 h and acetaminophen 1 g/8 h, alternating every 4 h.

Port-site infiltration was performed with 30 ml of bupivacaine 0.25%, applying 6 ml under the aponeurotic layer in each port.

TAP-lap was performed with 30 ml of bupivacaine 0.25%, applying it into the plane between the internal oblique and the

transversus abdominis muscles. The injection was performed at three levels, coinciding with the same dermatomes where the port sites were located. The injection was performed at the dermatomes, but lateral to the port sites. The infiltration was performed bilaterally with a volume of 5 ml in each injection place. The laparoscopic guidance consists in the insertion of the needle until the tip protrudes on the peritoneal layer, without traversing it. Then, the needle is retracted 3 mm into the abdominal wall, which is the estimated thickness of the preperitoneal space and the transversus abdominis muscle, so that the anesthetic drug is injected into the space between the internal oblique muscle and the transversus abdominis muscle. The injection of the anesthetic drug into this space induces the formation of a bulge, observed as a mild protrusion in the abdominal wall towards the peritoneum. The mild protrusion indicates that the injection place is correct (Figs. 1 and 2). A greater protrusion indicates that the drug has been injected in the preperitoneal space. In order to validate the technique, in the first ten patients the injections in the correct spaces were confirmed with ultrasonography.

When postoperative pain, as measured by VAS, overcame 50 mm at any moment in the postoperative course, 5 mg of subcutaneous morphine was administrated.

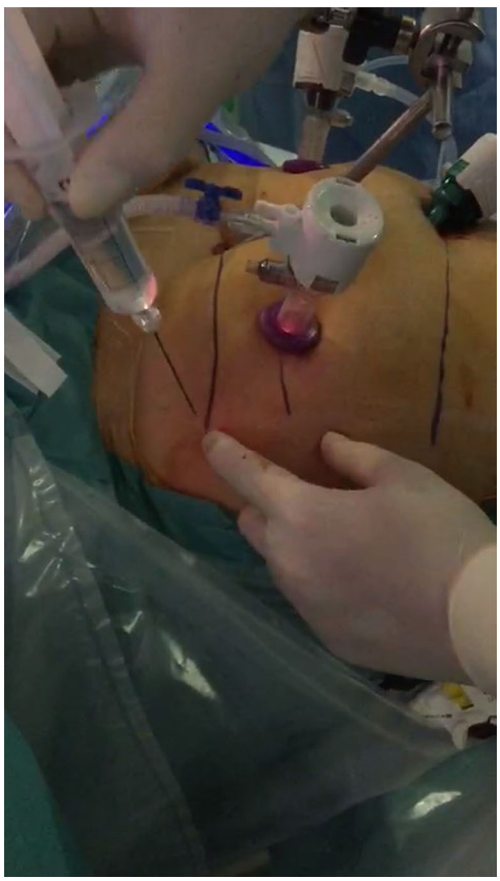

Fig. 1 The injection is performed at three levels, coinciding with the same dermatomes where the port sites were located and lateral to them. The infiltration was performed bilaterally

Variables

Analyzed variables included age, gender, anthropometric values (weight, BMI), operation time, postoperative complications, mortality, hospital stay, pain quantification as measured by visual analogic scale (VAS), ranging from 0 (absence of pain) to 10 (unbearable pain) 24 h after surgery, and morphine needs during the first 24 h. Pain quantification during the first 24 h was evaluated by a nurse blinded to the treatment applied.

Statistics

Statistical analysis was performed with the statistical software SPSS 19.0 for Windows. Quantitative variables that followed a normal distribution were defined by the mean and standard deviation. For non-Gaussian variables, the median and range were used. Qualitative variables were defined by number and percentage of cases.

Comparison of variables was performed with the Student *t* test (the Mann-Whitney test in non-Gaussian variables). Comparison of qualitative variables was performed with the chi-square test; in those cases with fewer than five observations in the cell, the Fisher exact probability method was used. A $p < 0.05$ was regarded as significant.

The study was approved by the local ethics committee and informed consent was obtained from all the patients.

Results

One hundred and forty patients were included, 70 in each group, consisting in 80 females (57.1%) and 60 males (42.9%), with a mean age of 41.8 + 7.3 years and a mean BMI of 47 + 4.5 kg/m^2. There were no significant differences in age, gender, comorbidities, weight, or BMI between groups (Table 1).

The mean operation time was 83.3 + 15.6 min in TAP-lap and 80.5 + 14.4 min in PSI (NS). Postoperative complications appeared in three patients (2.1%), one jejuno-jejunal anastomotic leak in TAP-lap and one gastrojejunal leak and one hemoperitoneum in PSI (NS). All the patients with complications required reoperation. There was no mortality.

When analyzing the postoperative pain, patients presenting complications were excluded from the analysis. Thus, 69 patients were included in TAP-lap and 68 in PSI. The mean postoperative pain, as measured by VAS, 24 h after surgery was 16.8 + 11.2 mm in PSI and 10 + 8.1 mm in TAP-lap ($p = 0.001$). Morphine rescues were necessary in 13.2% in PSI and 2.9% in TAP-lap (OR 4.96; 95% CI 2.3–11.2; $p = 0.026$). The mean hospital stay was 2.1 + 1.2 days in TAP-lap and 2.9 + 1.3 days in PSI ($p = 0.019$). Hospital discharge during the first 48 h after surgery was possible in 52.9% of the patients in PSI and 71% in TAP-lap (OR 4.75; 95% CI 2.1–10.8; $p = 0.029$).

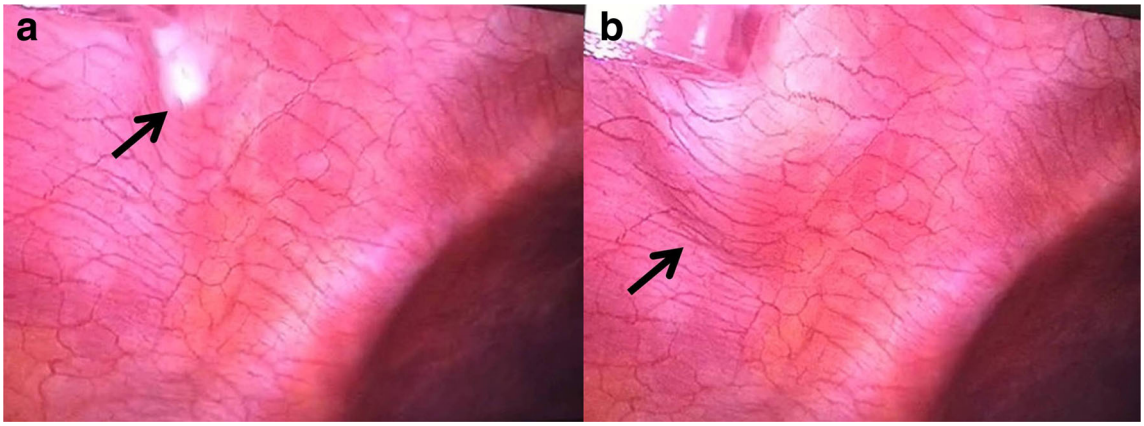

Fig. 2 **a** The laparoscopic guidance consists in the insertion of the needle until the tip protrudes on the peritoneal layer, without traversing it. **b** Then, the needle is retracted 3 mm into the abdominal wall, which is the estimated thickness of the preperitoneal space and the transversus abdominis muscle, so that the anesthetic drug is injected into the space between the internal oblique muscle and the transversus abdominis muscle. The injection of the anesthetic drug into this space induces the formation of a bulge, observed as a mild protrusion in the abdominal wall towards the peritoneum

Discussion

Postoperative pain after bariatric surgery presents three components: parietal pain associated to the damage in the abdominal wall during the insertion of the ports, visceral pain related with the handling of the gastrointestinal serosa, and the pain associated to the pneumoperitoneum, causing a diaphragmatic irritation and usually located under the left shoulder. It has been estimated that after laparoscopic surgery, parietal pain represents 50–70% of the total pain, visceral pain (10–20%), and the pain related to the pneumoperitoneum 20–30% [15, 16].

Port-site infiltration with local anesthetics as analgesic method has been described for many laparoscopic procedures as a method to reduce the parietal pain. It is considered an easy, safe, and cheap method. Notwithstanding, there is some controversy about its analgesic efficacy, existing series describing an excellent postoperative analgesia [17, 18], but other authors could not demonstrate this efficacy [19]. Specifically referring to bariatric surgery, a publication of a Spanish group reports that the association of port-site infiltration with bupivacaine achieves a reduction of postoperative pain during the first 4 h, but they did not observe differences after this time. Systemic absorption and peak plasma levels of local anesthetic following blocks in bariatric patients have not been analyzed, but this would not be probably associated with the efficacy and duration of the analgesia, as the effect is mainly local, but with the direct contact of the drug with the nerve fiber, blocking nervous conduction by reducing the membrane permeability to sodium [20]. The main problem of port-site infiltration is that the subaponeurotic administration of the drug is performed in a blind manner, especially in morbidly obese patients, as the aponeurotic layer cannot be seen at the time of the infiltration and the location of the aponeurosis is just estimated as a point of higher resistance during the introduction of the needle. To minimize this estimative infiltration, the ultrasonographic guidance has been developed in order to clearly visualize the placement of injection of the drug.

Table 1 Distribution of age, gender, comorbidities, and preoperative anthropometric measures between groups

	TAP-lap	PSI	*p*
Age (years)	41.9 + 5.9	41.7 + 7.2	NS
Females/males	40/30	40/30	NS
Comorbidities			
Diabetes mellitus	35.9%	35.7%	NS
Dyslipidemia	38.6%	34.3%	NS
Hypertension	41.4%	42.9%	NS
SAHS	62.9%	65.7%	NS
Weight (kg)	124.8 + 20.4	124.8 + 20.4	NS
BMI (kg/m^2)	47.4 + 5.2	46.5 + 4.3	NS

NS non-significant, *SAHS* sleep apnea-hypopnea syndrome

Andersen et al. [21] performed a recent systematic review of randomized trials involving the analgesic treatment in laparoscopic gastric bypass surgery. Though the methodological quality of most included studies was limited, they conclude that the administration of nonsteroidal anti-inflammatory drugs, local anesthetics (intraperitoneally or subfascially/subcutaneously), transversus abdominis plane block, dexmedetomidine, and ketamine may improve analgesia compared to placebo. No studies compared the different analgesic schemes between them, but many anesthesiologists defend TAP blockade as superior to port-site infiltration and, if they are going to perform an ultrasound-guided infiltration, they prefer to carry out a TAP block rather than a port-site infiltration.

The TAP block has been previously studied in patients undergoing different open and laparoscopic surgical procedures. Most studies have demonstrated that the TAP block

decreases peri- and postoperative pain and reduces the use of opioids [10]. Recent studies have shown similar benefits in obese patients undergoing laparoscopic colorectal surgery and Cesarean delivery [22, 23]. Several authors defend that the ultrasound guidance allows the identification of the layers of the abdominal wall even in obese patients, where landmarks are often obscured by the body habitus [24]. However, due to deep anatomic location of structures and nerves, the ultrasound beam travels a greater distance, leading to beam attenuation. Moreover, the image quality through fat may be poorer as the adipose tissue has a nonlinear relationship to frequency, whereas most biological tissues have linear relationship. In addition, the irregularly shaped adipose layers lead to uneven speed of sound causing phase aberration of the sound field, so that, above the focus of the transducer, there are differing speeds of sound, leading to mismatch of acoustic impedance at the fat/muscle interfaces. In obese patients, there is an increase in the number of reflective interfaces not only leading to more echoes, but also decreasing the incident of sound available to penetrate deeper tissues, such as nerves, vessels, or other targeted structures [25–27]. In our experience, many anesthesiologists refer difficulties in the identification of the transversus abdominis plane when performing ultrasound-guided TAP blocks, because of the thickness of the subcutaneous adipose tissue. Thus, we decided to perform this procedure with laparoscopic guidance. It is true that laparoscopic guidance is not as exact as the ultrasound one, as the muscular layers cannot be identified. We just identify the tip of the needle when protruding on the peritoneum and we retract it at 3 mm, based on the estimated thickness of the transversus abdominis muscle and the preperitoneal space. Moreover, the bulge obtained must suggest that the infiltration is not performed in the preperitoneal layer, which will provoke a greater bulge, or in the space between both oblique muscles, which will not perform any bulge as the internal oblique muscle has greater thickness that the transversus abdominis. To validate our technique, the correct injection place was confirmed with ultrasonography.

Said et al. have recently published a novel method of continuous TAP blocks via laparoscopically placed catheters for bariatric surgery. They performed a laparoscopic dissection of the space between transversus abdominis and internal oblique muscles, placing there a catheter for continuous infusion of local anesthetics, and obtained a significant reduction of postoperative pain and opioid needs. In the performance of this approach, these authors confirm that the transversus abdominis muscle has a width of 2–3 mm, as we hypothesized in our technique, and the infusion tests they performed with normal saline obtained similar bulging images to that we observed in our patients [28].

Laparoscopic-guided TAP block implied in our patients a lower postoperative pain and lower requirements of opioid rescues. It is true that a reduction in pain perception from 16.8 to 10 mm seems not to be a real difference, as the range between 5 and 44 mm is considered as mild pain. However, the significant reduction of morphine needs from 13.2% of the patients to 2.9% is clinically relevant, and altogether, this greater analgesic effect leads to a shorter hospital stay and a hospital discharge within the first 48 h after the surgery in 18% more patients. These results suggest that laparoscopic-guided TAP block can be a useful tool for the multimodal management of postoperative pain.

The main limitation of the technique is that it is operator-dependent and requires a certain learning curve or validation in the first cases with ultrasonography, in order to confirm the infiltration in the correct space. Another conflictive point is the place of needle insertion, as this is totally empirical in terms of dermatomes and could lead to differences in results. A dermatome is an area of skin that is mainly supplied by a single spinal nerve. The exact location of dermatomes and the area of skin they represent are variable among subjects. Despite performing the laparoscopic-guided TAP laterally to the port sites, but not far away from them, it is possible that in several cases, the anesthetic infiltration does not exactly coincide with the same dermatome of the port site, leading to a reduced analgesic effect.

Conclusion

Laparoscopic-guided TAP block can reduce postoperative pain, opioid needs, and hospital stay, when compared with port-site infiltration with the same anesthetic drug, without increasing operation time.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Statement of Informed Consent Informed consent was obtained from all individual participants included in the study.

Statement of Human Rights All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments.

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