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Original Research Article

The Bilateral Tap-Block Ultrasound-Guided in Laparoscopic Abdominal Surgery: Evaluation of a Curare-Free Anaesthetic Protocol

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Abstract: ***Introduction:*** The transverse abdominal plane block or TAP block consists of injecting a local anaesthetic between the internal oblique and transverse muscles. Its contribution to muscle relaxation during laparoscopic surgery has been little studied. ***Material and Method***: We carried out a 2-years prospective, descriptive and analytical randomised study blinded to the surgeon conducted in the operating theatre of the Saint Louis Regional Hospital Centre. Patients were randomised into two groups: those who received vecuronium after rapid sequence induction (group V) and those who received bilateral TAP block without curares (group T). Anamnestic, clinical, anaesthetic, surgical and evolutionary aspects were collected and analysed. The main evaluation criteria were: pneumoperitoneum pressure, exhaled CO2, respiratory motor pressure and surgeon satisfaction scale. ***Results:*** We collected 61 patients admitted for laparoscopic abdominal surgery. The mean age was 32.9 years with a standard deviation of 14.5. Appendicitis was the indication in 55% of cases. The Propofol-celocurine-TAP-block anaesthetic protocol was used in 25 patients, i.e. in 41% of cases, and 59% of patients had undergone a conventional induction using vecuronium. The mean pressure of the pneumoperitoneum was 11.3 mmHg for the conventional induction group and 12.6 mmHg for the TAP-block group. The mean respiratory motor pressures were 12 cmH2O for the conventional induction group and 13.7 cmH2O for the TAP-block group. The mean value of exhaled CO2 was 37.5 mmHg. Fentanyl reinjections were more frequent in the conventional induction group in 55.6% of cases. The mean VAS at 6 hours post-op was 4.5 for the conventional induction group and 3 for the TAP-block group. ***Discussion/Conclusion:*** The ultrasound-guided trans-abdominal-pelvic block remains an effective, durable and reproducible technique. Its advantages in terms of postoperative analgesia are well known. In addition, its selective effects on muscle relaxation and tone make it an excellent alternative to curarisation for intraperitoneal laparoscopic abdominal surgery.

Keywords: TAP-bloc, curares, laparoscopy, monosynaptic reflex.

INTRODUCTION

The transversus abdominis plane block (TAP block) consists of injecting a local anaesthetic between the internal oblique and transverse abdominal muscles to obtain analgesia of the abdominal hemipelvis. An interesting alternative to multimodal analgesia, this procedure helps to reduce the consumption of opioid analgesics in the postoperative period. However, its contribution to muscle relaxation during laparoscopic surgery has been little studied.

The general aim of this study was to determine the general value of TAP-block in laparoscopic abdominal surgery. The specific objectives were to determine the contribution of TAP-block to curare-free anaesthesia and morphine-sparing strategies.

MATERIAL AND METHOD

We conducted a prospective, randomised 1 in 1, surgeon-blinded study. The general objective of the study was to evaluate the contribution of TAP block to muscle relaxation during laparoscopic surgery. The

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study was conducted in the operating theatre of the Saint Louis Regional Hospital in Senegal. The study period was from 1 January 2019 to 31 December 2021. We included all patients under 75 years of age with an ASA I to III score scheduled to undergo laparoscopy for supra- or sub-mesocolic surgery.

After rapid sequence induction, a bilateral trans-abdominal-pelvic block was performed blinded to the surgeon for the TAP group. This block consisted of placing a high-frequency ultrasound probe midway between the iliac crest and the costal margin on the mid-axillary line. Under in-plane ultrasound control, a 50 mm needle is inserted and its hyperechoic tip is checked. As soon as the tip of the needle is positioned between the fascia of the internal oblique and transverse muscles (Image 1), a local anaesthetic is injected. In our study, we opted for a local anaesthetic mixture of xylocaine 2% and bupivacaine 2.5 mg/ml. Each patient was injected with 20 ml of the mixture on each side. The block was considered effective when a hypoechoic biconvex lens image was obtained between the fascia of the transversus abdominis and the medial oblique muscle (Image 2).

Patients were randomised into two groups: those who had received vecuronium during induction (group V) and those who had received bilateral TAP block without curares (group T). In our study, for group V, deep curarisation was targeted and for group T, only the criterion of effectiveness of the TAP-block judged on the satisfaction of the ultrasound images and the absence of reaction to the incision were sufficient to authorise insufflation.

For each patient, we collected anamnestic, clinical, anaesthetic, surgical and evolutionary data. The main assessment criteria were: pneumoperitoneum pressure, exhaled CO2, respiratory motor pressure and surgeon satisfaction scale. The data collected were analysed using Epi-Info 7.2 and Microsoft Excel, and a relationship was considered statistically significant when the p-value < 0.05.

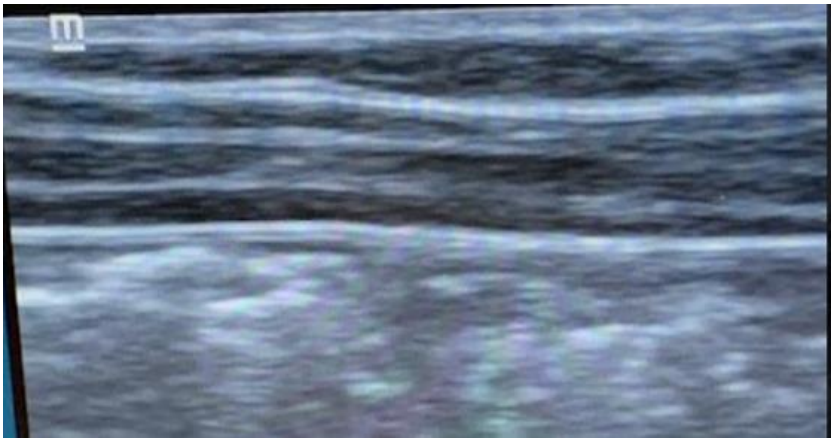

Image 1: Transverse ultrasound section showing the muscles of the abdominal wall

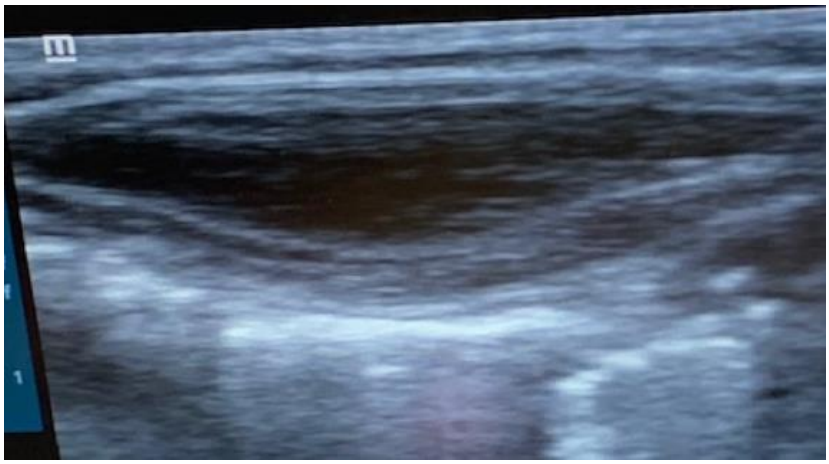

Image 2: Transverse ultrasound section showing the appearance of a biconvex lens between the fascia of the internal oblique and transverse muscles obtained after injection of the local anaesthetic mixture

RESULTS

We enrolled 61 patients in our study. The mean age was 32.9 years with a standard deviation of 14.5 years (maximum age: 58, minimum age: 18). The mean ASA score was 1 with a standard deviation of 0.25. The mean body mass index was 27 kg/m2, with a minimum of 18 and a maximum of 31. The main indications for laparoscopic surgery were acute appendicitis in 31

patients (50.8% of cases), lithiasis gallbladder in 11 patients (18% of cases) and inguinal hernia in 8% of cases. Table 1 summarises in absolute value and percentage all the surgical indications in our series. Antibiotic therapy or antibiotic prophylaxis was administered in all our patients according to Althermayer's classification. Protocol V was used in 36 patients, i.e. in 59% of cases, and protocol T was used in 25 patients, i.e. in 41% of cases. All our patients received orotracheal intubation after induction. All our patients received volume-controlled ventilation. The overall mean respiratory motor pressures were 12.4 mmHg (extremes: 15 and 7 mmHg). The overall mean value for pneumoperitoneum pressures was 11.06 mmHg (extremes: 15 and 10 mmHg). The mean exhaled CO2 level was 39.6 mmHg (E: 51 and 35 mmHg). Table 1 shows the values of the various assessment parameters in the two groups.

Two patients experienced arterial hypotension, which was controlled by filling with 500 ml of crystalloids and direct intravenous administration of ephedrine. Reinjections of fentanyl were necessary in 22 patients, i.e. in 36% of cases. Conversion to laparotomy was necessary in 3 patients, representing a conversion rate of 4.9% (one patient in group T and 2 patients in group V). The average duration of surgery was 120 minutes, with extremes of 35 minutes and 210 minutes. Patients woke up on the operating table in 100% of cases. The surgeon's mean global satisfaction scale was 2.7 (extremes: 1- 3). The mean pain at 6 hours post-op assessed using the numerical scale was 4.03 (extremes: 6 - 2), and the mean pain at 24 hours post-op assessed using the same scale was 2.4 (extremes: 5 - 0).

Correlational analysis: the curves for respiratory motor pressures and variations in pneumoperitoneum were superimposable for groups V and T. However, the variations were statistically insignificant ($p > 0.05$). The exhaled CO2 curve for group T had a smaller area under the curve than for group T and the variations between the two curves were statistically insignificant. In addition, at least one morphine reinjection was required intraoperatively in 47.8% of cases in group V and 16% of cases in the TAP block group, with a statistically significant relationship ($p < 0.05$). In our study, subject to the size of the sample, TAP block is therefore a factor that reduces morphine re-injections. The mean pain value at 24 hours post-op was 2.4 according to the numerical pain scale. For the V group, the mean pain scale was 3.5 for the T group and 1 for the V group, with a statistically significant correlation ($p < 0.05$). In our study, TAP block emerged as a protective factor for postoperative pain at H24.

Figures 1 to 5 show the comparative analysis between the TAP block group without curares and the Vécuronium group.

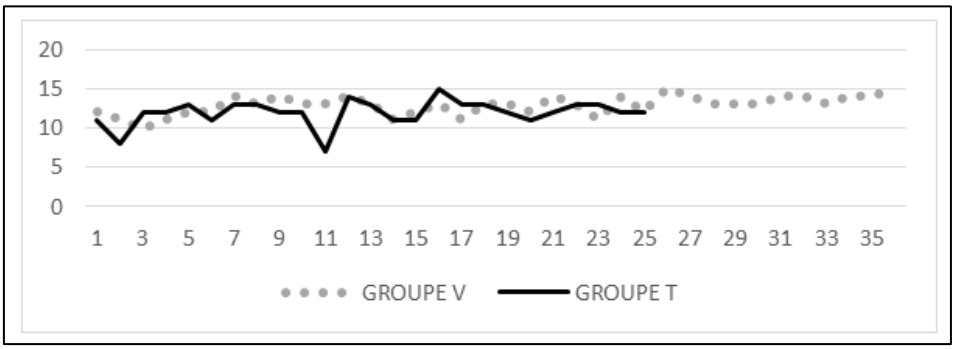

Figure 1: Curves showing the evolution of respiratory motor pressures in the T and V groups

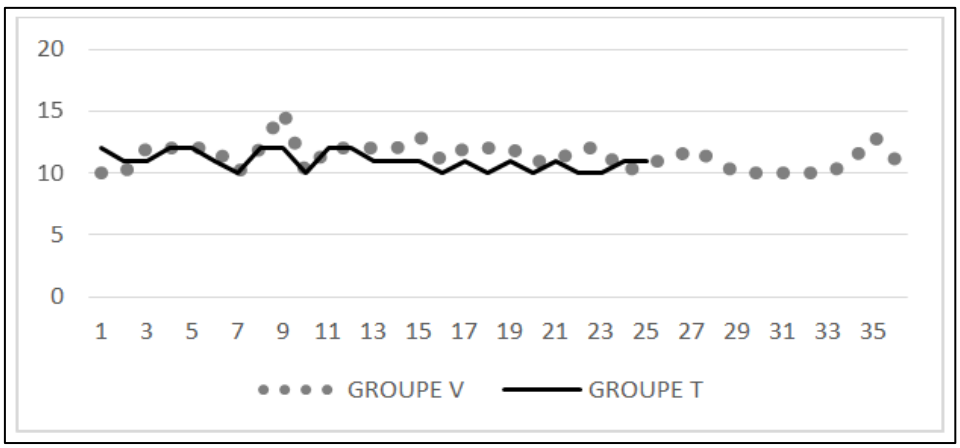

Figure 2: Evolutionary curves of pneumoperitoneum pressures in groups T and V

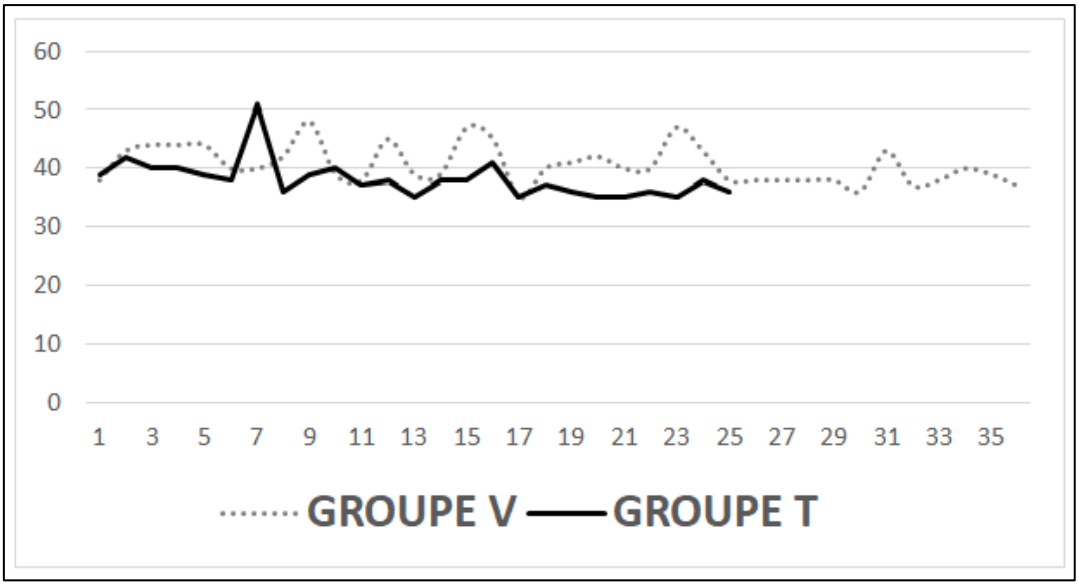

Figure 3: Exhaled CO2 pressure curves for groups T and V

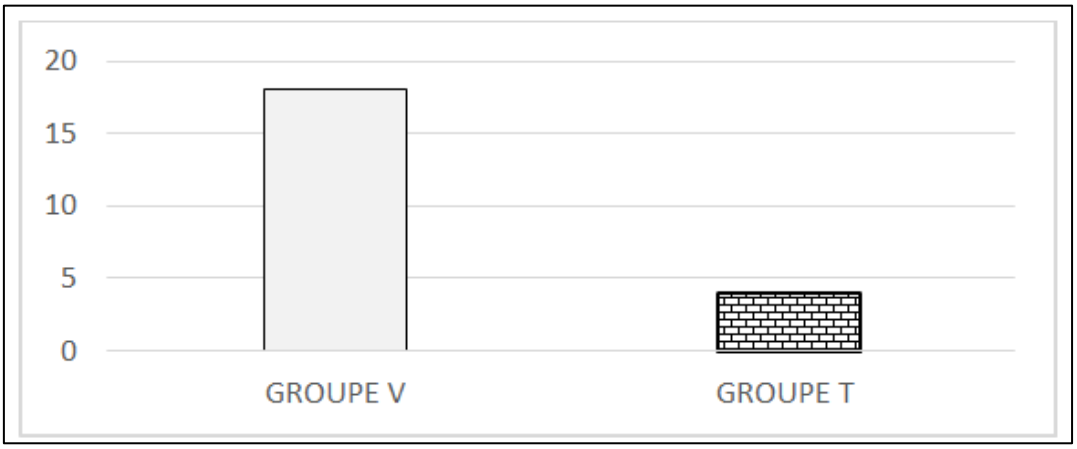

Figure 4: Representation of the two groups according intraoperative morphine reinjections

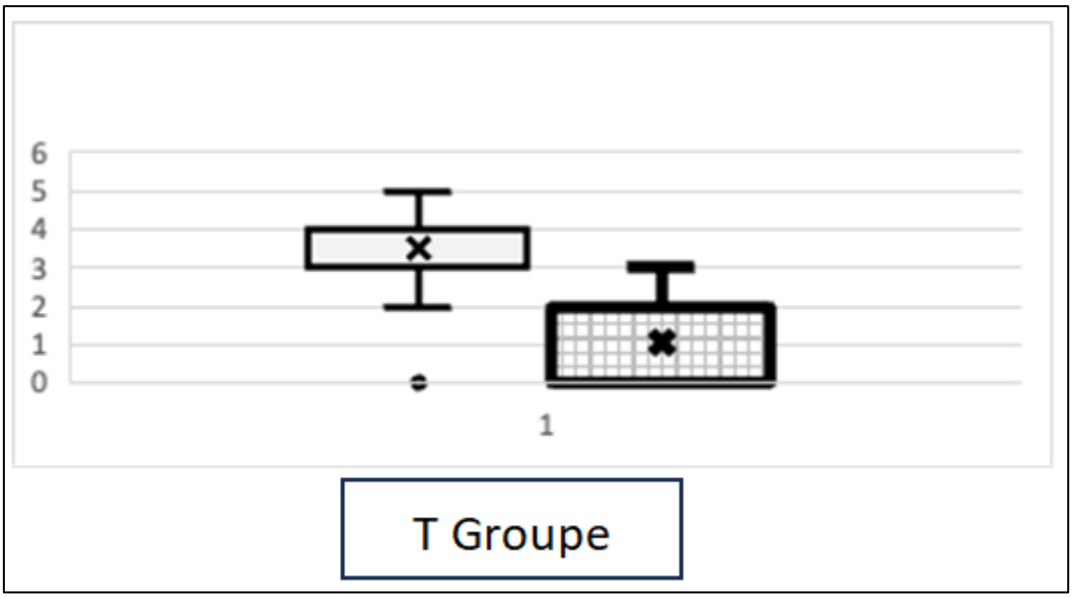

Figure 5: Representation of the two groups according to pain at 24h

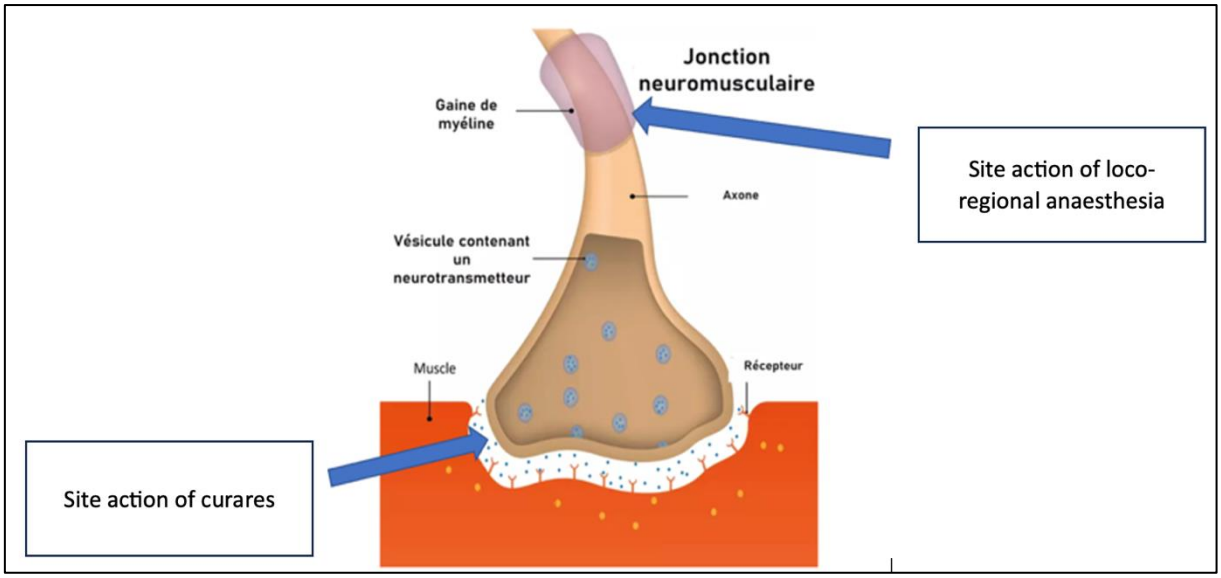

Figure 6: Illustration of curare vs Loco-regional action point

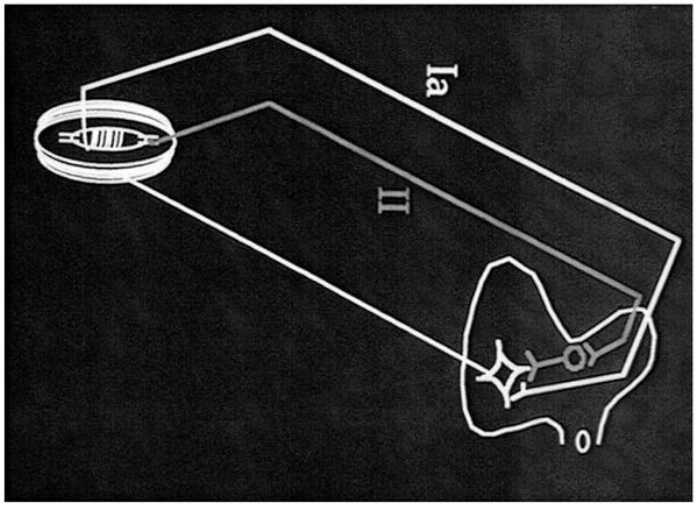

Figure 7: Schematic representation of fibres Ia and II of the myosynaptic reflex (14)

Table 1: Descriptive analysis of the different assessment parameters in the two groups

AVERAGE	OVERALL	V GROUP	T GROUP
Pneumoperitoneum pressure ($cmHO_2$)	11.06 (Max : 15 Min : 10)	11.9	11.04
Max exhaled CO2 (Mmhg)	39.6 (Max : 51 – Min : 35)	39.3	37.1
Driving Respiratory Pressure 12.45	12.45 (Max : 15 – Min : 7)	12.6	12.2
Intraoperative morphine re-injection	22 patients	18 patients (81.8%)	04 patients (18.1%)
Score Satisfaction	2.7 (Max : 3 – Min : 1)	2.3	3

DISCUSSION

Laparoscopic techniques have revolutionised abdominal surgery and have led to changes in anaesthetic management. The physiological changes caused by pneumoperitoneum are minimal at pressures of no more than 12 mmHg, making absolute contraindications rare. General anaesthesia with orotracheal intubation and controlled ventilation is generally proposed to reduce the increase in PaCO2 and to avoid the ventilatory disturbances associated with pneumoperitoneum [1]. The use of a positive expiratory pressure of 5 cmH2O improves oxygenation [2]. The laryngeal mask has been used during laparoscopic gynaecological surgery where it has been shown that there is no increase in reflux. This cannot be extrapolated to supramesocolic surgery where there is a definite risk of passive regurgitation of gastric contents. In addition, mechanical ventilation is often poor with a conventional laryngeal mask. In contrast, the laryngeal mask ProSealTM or I-Gel masks would provide better ventilation conditions, which could even be equivalent to endotracheal intubation [3]. It has been shown that a 12% to 16% increase in ventilatory flow enables a PaCO2 close to the values before insufflation to be maintained [4] and that the partial pressure of CO2 in exhaled air at the end of expiration (ETCO2) is a fairly

close approximation of the PaCO2 in healthy patients due to undergo laparoscopic cholecystectomy. However, in patients with cardiopulmonary pathology, this relationship between PaCO2 and ETCO2 is no longer valid [5]. Preoperative assessment of pulmonary function shows that a decrease in forced expiratory volume in one second (FEV1) and vital capacity is a good indicator of the occurrence of hypercapnia during cholecystectomy [6]. If hypercapnia with respiratory acidosis occurs, the insufflation pressures of the pneumoperitoneum should be reduced and the laparoscopy may have to be converted to a laparotomy.

In our group, general anaesthesia with orotracheal intubation was used and the ventilatory parameters were adapted to the pressure and ETCO2 values, with no cases of lasting hypercapnia. In the TAP group, only one conversion to laparotomy was indicated in the event of a difficult appendicular resection. Classically, the use of morphine can be accompanied by spasms of the sphincter of Oddi, which can interfere with the interpretation of intraoperative cholangiograms, and no study of this phenomenon during laparoscopic gallbladder surgery has been published to date [7]. In our study, all patients received morphine (fentanyl 3ug/kg) immediately after orotracheal intubation and morphine reinjections were most common in the curare group (group V), with a statistically significant relationship ($p<0.05$). In the context of laparoscopic surgery, curarisation may seem useful at the time of the creation of the pneumoperitoneum as part of the prevention of iatrogenic trocar accidents, to increase the working space and at the time of fascial closure of the trocar orifices [8]. In abdominal surgery, deep curarisation improves operating conditions, by allowing adequate exposure, both in laparotomy and even more so in laparoscopy [9]. In its latest formalised expert recommendations, published in 2018, the French Society of Anaesthesia and Intensive Care recommends the use of fast-acting curares to facilitate tracheal intubation and reduce the risk of pharyngolaryngeal trauma. It also recommends the use of intermediate-duration curares to facilitate the operative procedure in abdominal surgery by laparotomy or laparoscopy [10]. However, for the latter indication of curares in laparoscopic surgery, the argument was based on three studies concerning respectively prostate surgery by laparotomy [11] and laparoscopic cholecystectomies and hysterectomies with a placebo control group or receiving a low dose of curare. These studies highlighted the improvement in surgical conditions during intraoperative curarisation [12]. However, it should be noted that there is a difference in protocol between these studies, in which the control group was subjected to a placebo effect, and our study, in which the control group was subjected to a trans-abdominal-pelvic block likely to affect muscle relaxation and/or tone. Martini *et al.*, in their study, showed that deep neuromuscular block obtained by a post-tetanic count of between 1 and 2 was associated with an improvement in the quality of surgical conditions compared with moderate block in retroperitoneal laparoscopy, without compromising the patients' peri- and postoperative cardiorespiratory conditions [9]. Furthermore, in 2018, the SFAR drew attention to the fact that the data in the literature are insufficient to establish a recommendation on the level of the neuromuscular block to be achieved (moderate versus deep) in abdominal surgery by laparotomy or laparoscopy [8]. In our study, evaluation of the surgical conditions showed that there was no statistically significant difference between the TAP group and the curare group. This lack of difference in our series between the two groups raises two hypotheses:

- Hypothesis 1: either the TAP block produces a deep muscle block, which is not very obvious given the concentrations of local anaesthetics used (bupivacaine 2.5 mg/l).
- Hypothesis 2: either the TAP block was responsible for a mild to moderate muscle block.

This last hypothesis seems to be the most plausible under the conditions of our study. From a physiological point of view, two elements are responsible for the muscle tension that can cause discomfort during laparoscopy: muscle contraction and/or resting muscle tone. To overcome muscular contraction, the anaesthetist uses curares or TAP blocks in concentrations that cause a motor block. Non-depolarising curares (vecuronium, atracurium, rocuronium) act at the neuromuscular junction by blocking neuromuscular transmission resulting from competition for the occupation of postsynaptic receptor subunits between the natural agonist, acetylcholine, and an antagonist, the muscle relaxant [13]. The curare or muscle relaxant prevents electrical signal transduction by blocking the opening of sodium channels. Motor TAP-Block acts upstream of the motor plate by inhibiting the passage of nerve impulses and preventing the synthesis of acetylcholine. With concentrations that induce motor block (bupivacaine 5mg/ml or ropivacaine 7.5 to 10 mg/ml, the TAP block has the same effects as curarisation by inducing motor block. Figure 6 illustrates this hypothesis by highlighting the sites of action of the two techniques (curares and ALR-motor block). However, in our study, we used analgesic doses (Bupivacaine 2.5mg/ml and xylocaine 1%). The addition of lidocaine was justified to obtain a rapid onset of action. In our study, the surgical comfort obtained in patients in the TAP group may be secondary to the abolition of the myosynaptic reflex of the abdominal wall muscles which is inhibited by TAP block with low concentrations (bupivacaine 2.5mg/ml).

This myotatic reflex, responsible for the contraction of the muscle following its lengthening, was described in decerebrate cats in 1924 by Liddel and Sherrington. Several steps were then necessary to characterise the muscle receptors that give rise to the reflex, the afferent sensory fibres and the synaptic link between these afferent fibres and the motor neurons. It

was Llyod, in 1943, who demonstrated the monosynaptic link between fibre Ia from the central part of the neuromuscular spindle and the α motor neuron. Most of the studies devoted to the stretch reflex, both in animals and in normal or spastic humans, focused on this study of the myosynaptic reflex. However, the existence of a second category of sensory fibres derived from the neuromuscular spindle (fibres II) of smaller calibre than fibres Ia, but equally sensitive to the phasic and tonic components of the stretch, and a few experiments, should have led to discussion of their involvement in the genesis of the static portion of the stretch reflex, especially as some early observations made in humans suggested the existence of two distinct components in the stretch reflex (Figure 7) [14]. It is probable that TAP-block performed with analgesic concentrations leads to the blocking of these small sensory fibres from the neuromuscular spindle (fibre II) [14]. However, this remains a hypothesis, and the next step requires animal studies to confirm this perspective. The use of antagonists must take into account the increased risk of postoperative nausea and vomiting compared with residual curarisation. To prevent and limit the incidence of postoperative nausea and vomiting, often associated with laparoscopic surgery, many studies advocate the systematic use of antiemetics, particularly in patients at risk (APFEL score > 2) [1]. In our study, the use of curare agonists was necessary in 2 patients in group V (5%) and no cases of postoperative nausea and vomiting were reported. Currently, as part of accelerated rehabilitation programmes after surgery, the preoperative administration of single-dose glucocorticoids is recommended to reduce complications and length of stay in cases of major abdominal surgery [15]. Finally, it is recommended that curarisation be monitored for any indication of its use. Curarisation should be monitored in the eyebrow muscle, as it has similar curarisation kinetics to the muscles of the pharyngolaryngeal junction, and decurarisation should be monitored in the adductor muscle, which is the last muscle to decurarise [10]. The use of curares is associated with a risk of residual curarisation with pneumopathy and apnoea which have been described postoperatively [15]. The issue of residual curarisation was raised as early as 1979 by the Viby-Mogensen team [17]. In this study, which included 72 patients receiving long-acting curares (d-tubocurarine, gallamine and pancuronium), residual curarisation assessed by instrumental monitoring and defined by a T4/T1 ratio < 0.7 was observed in 42% of patients [17]. Even with short- or intermediate-acting drugs, residual curarisation remains a possibility. Debaene *et al*., demonstrated that two hours after a single injection of an intermediate-acting curare (atracurium, vecuronium or rocuronium) for intubation, residual curarisation, defined as T4/ T1 < 0.9, was still present in 37% of patients [18]. Clinical tests, such as the head lift, had a poor sensitivitý for detecting residual curarisation, confirming the data observed by Viby-mogensen 25 years earlier [19].

Nowadays, in the absence of preventive measures, residual curarisation is still present in almost one in two patients in the post-operative period. The situation seems just as alarming even when the rules of good practice are applied. Murphy *et al*., evaluated the presence of residual curarisation immediately after extubation in 120 patients [20]. Quantitative measurement of the T4/T1 ratio before extubation significantly reduces the frequency of occurrence of residual curarisation but does not eliminate it. In our study, there were no cases of residual curarisation, and a delay in awakening linked to high morphic impregnation was observed in patients in group V who had received a morphine re-injection intraoperatively. Given this concept of uncertainty in the face of residual curarisation, the use of the TAP block without curares for laparoscopic abdominal surgery is highly relevant.

CONCLUSION

Ultrasound-guided Trans-abdomino-pelvic block remains an effective, durable and reproducible technique. Its benefits in terms of postoperative analgesia are well known. In addition, its selective effects on muscle relaxation and tone make it an excellent alternative to curarisation for intraperitoneal laparoscopic abdominal surgery.

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

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