Comparative effectiveness of continuous subcostal transversus abdominis plane block *versus* thoracic epidural analgesia in postoperative pain management following major open abdominal surgery: a prospective observational study

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Abstract

This observational study compared the effectiveness of continuous subcostal transversus abdominis plane (TAP) block with bilaterally placed catheters *versus* continuous thoracic epidural analgesia (TEA) in managing postoperative pain following major open abdominal surgery. Thirty-one patients were enrolled between July 2019 and September 2020 at the Policlinico Paolo Giaccone in Palermo and divided into two groups. Postoperative pain, opioid consumption, incidence of postoperative nausea and vomiting (PONV), hemodynamic stability, and patient satisfaction were evaluated.

No significant differences were observed in the number rating scale (NRS) values at 0, 6, 12, and 24 hours between groups. Only 3 patients in the TAP group required opioids in the first 24 hours; however, no differences were observed in median opioid consumption between groups (TEA 0.00 [0.00-0.00]; TAP 0.00 [0.00-0.00], p=0.08).

Hemodynamic stability was evaluated using mean arterial pressure and heart rate values, with no significant differences found for either parameter over time. The incidence of PONV was similar in both groups (p=0.47).

The continuous TAP block represents an effective, less invasive alternative to TEA, particularly in patients with contraindications to neuraxial analgesia, aligning with Enhanced Recovery After Surgery (ERAS) protocols and the procedure-specific postoperative pain management (PROSPECT) methodology.

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Ethics approval and consent to participate: the study has been approved by the local ethics committee (verbal number 6/2020, CE 150109). Written informed consent was obtained from all participating patients.

Availability of data and materials: the datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Introduction

Effective postoperative pain management is a cornerstone of care in patients undergoing major abdominal surgery.[1] Adequate analgesia not only improves patient comfort but also plays a critical role in enhancing postoperative outcomes by promoting early mobilization, reducing the risk of thromboembolic events, improving respiratory function, and accelerating the return of gastrointestinal motility. In this context, modern multimodal analgesia strategies have become integral to Enhanced Recovery After Surgery (ERAS) protocols, which advocate for a personalized and multidisciplinary approach to perioperative care.[1,2]

Thoracic epidural analgesia (TEA) has traditionally been considered the gold standard for postoperative pain control in abdominal surgery. A substantial body of evidence supports its efficacy in reducing pain scores, minimizing systemic opioid requirements, and facilitating a more stable postoperative course. However, TEA is not without limitations. Potential complications such as hypotension, urinary retention, motor block,

and rare but serious neurological events can limit its use. Moreover, patients with coagulopathy, spinal deformities, or other contraindications may not be candidates for epidural catheter placement. The procedure also requires technical expertise and close monitoring, which may be challenging in resource-limited settings.[3]

In recent years, the transversus abdominis plane (TAP) block, particularly the continuous bilateral subcostal approach, has gained popularity as a viable alternative to epidural analgesia. The TAP block targets the somatic nerves of the anterior abdominal wall (T6-L1), providing selective analgesia without the systemic side effects commonly associated with neuraxial techniques.[4] The subcostal approach extends analgesic coverage to the upper abdomen, making it suitable for a wide range of open abdominal procedures.[5] The placement of catheters under ultrasound guidance for continuous infusion has further expanded its utility for prolonged postoperative pain management.

Despite its growing popularity, the evidence comparing continuous TAP block to epidural analgesia remains limited and somewhat conflicting. Some studies suggest that TAP blocks offer comparable analgesic efficacy with fewer hemodynamic complications and improved patient tolerance.[6,7] Others highlight the limitations of the TAP block in managing visceral pain, suggesting that it may be less effective compared with TEA.[8]

Given this background, the present observational study aims to compare the analgesic efficacy of continuous bilateral subcostal TAP block with continuous TEA in patients undergoing open major abdominal surgery within the framework of ERAS protocols and the procedure-specific postoperative pain management (PROSPECT) methodology,[9] with a lower hemodynamic impact and reduced invasiveness.

Materials and Methods

The study has been approved by the local ethics committee (verbal number 6/2020, CE 150109).

All consecutive patients scheduled for major abdominal surgery with an open laparotomic approach between December 2019 and September 2020 at the Paolo Giaccone Hospital were included.

Exclusion criteria included being under 18 years old, known hypersensitivity to the drugs used, undergoing anterior rectal resection, having a history of psychiatric disorders, having skin infections at the injection site, and lacking informed consent. Written informed consent was obtained from all patients involved in the study.

Perioperative management

According to local perioperative protocol, general anesthesia induction in patients undergoing surgery was performed with intravenous (IV) fentanyl, IV propofol, and maintained with a mixture of oxygen and sevoflurane or desflurane, or with total intravenous anesthesia (TIVA). Rocuronium was used as a muscle relaxant.

Intraoperative care was managed in accordance with standard practice.

Perioperative pain was managed with TEA or continuous TAP block according to the attending anesthesiologist's choice, without interference. The choice depended freely on the anesthesiologist's individual level of expertise and confidence with the technique.

Patients treated with TEA received boluses or continuous infusion of levobupivacaine through an epidural catheter positioned in a space between T9 and L4 before general anesthesia. At the end of the surgery, a continuous infusion of levobupivacaine 0.25% was started, with maintenance of analgesia *via* volumetric pump infusion at a rate ranging from 4 to 7 mL/h for the first 48-72 hours.

Regarding intraoperative management of patients treated with TAP block, 9 patients received a continuous infusion of remifentanil and a TAP block with 0.5% levobupivacaine, 100 mg/side, prior to peripheral catheter placement at the end of surgery; the other 6 patients received a bilateral single-shot subcostal TAP block before the surgical incision, followed by placement of bilateral peripheral nerve catheter at the end of surgery. In both cases, an infusion of 0.2% levobupivacaine was started through two elastomeric pumps with an infusion rate of 2 mL/h.

All patients also received three scheduled doses of paracetamol 1 g every eight hours and rescue doses of opioids (sublingual sufentanil) as needed to ensure pain control.

Continuous TAP block

Catheters were bilaterally inserted into the transversus abdominal plane with a subcostal approach under ultrasound guidance at the end of the procedure. Under sterile conditions, a high-frequency linear ultrasound probe was placed in the transverse plane between the iliac crest and the subcostal limit along the hemiclavear line. The fascial plane between the internal oblique and transversus abdominis muscles was identified (Figure 1). A Tuohy needle was inserted anteriorly along the ultrasound line and advanced mediolaterally toward the transverse plane of the abdomen, following the costal margin and progressively dissecting the fascia (Figure 2). After hydrodissection, the TAP catheter was then inserted into the transversus abdominis plane. TAP catheters were inserted to a depth of 4-7 cm, depending on several factors, including the depth of the fascial plane and the patient's body mass index (BMI). The catheters were connected to elastomeric pumps, and a continuous infusion of 0.2% levobupivacaine at 2 mL/h per side was started and maintained during the postoperative period (Figure 3).

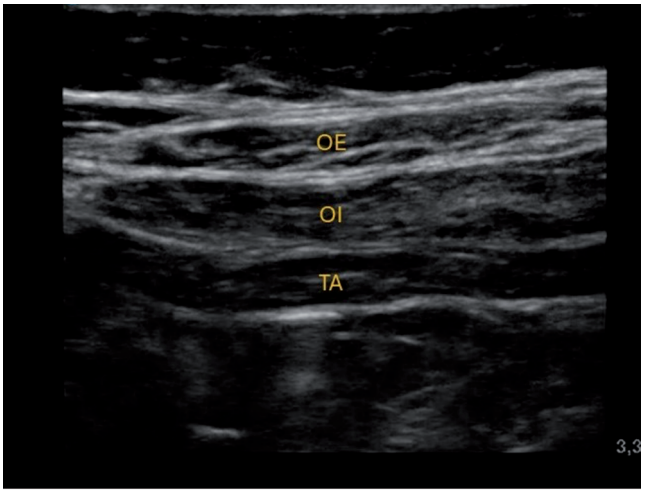

Figure 1. Sonoanatomy of transversus abdominis plane block. OE, external oblique muscle; OI, internal oblique muscle; TA, transversus abdominis muscle.

Data collection and analysis

Demographic characteristics, type and duration of surgery, timing and dosage of pain-related medications, and data regarding postoperative course were collected. Pain was assessed using the number rating scale (NRS) and was recorded at the end of the surgical procedure (T0) and at 6, 12, and 24 hours. Total opioid consumption was measured at the end of the 24-hour observation period. Additionally, heart rate and mean arterial pressure were monitored at the end of the procedure and at 6 and 12 hours to evaluate hemodynamic stability, as well as the incidence of postoperative nausea and vomiting (PONV) during the first 24 hours after surgery.

PONV scores were rated as absent = 0 and presence of nausea and/or vomiting = 2. Patients' satisfaction with analgesia during the postoperative period was recorded using the Likert scale at the end of 24 hours. The scale included 5 scores: very dissatisfied = 1, dissatisfied = 2, not very satisfied = 3, satisfied = 4, and very satisfied = 5.

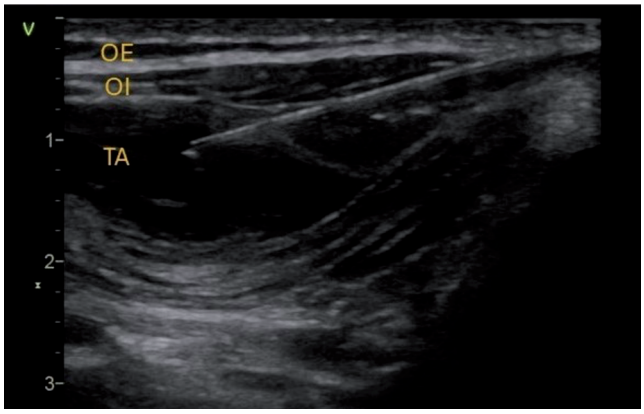

Figure 2. The needle is inserted with an in-plane approach in the plane between the internal oblique muscle and the transversus abdominis muscle. OE, external oblique muscle; OI, internal oblique muscle; TA, transversus abdominis muscle.

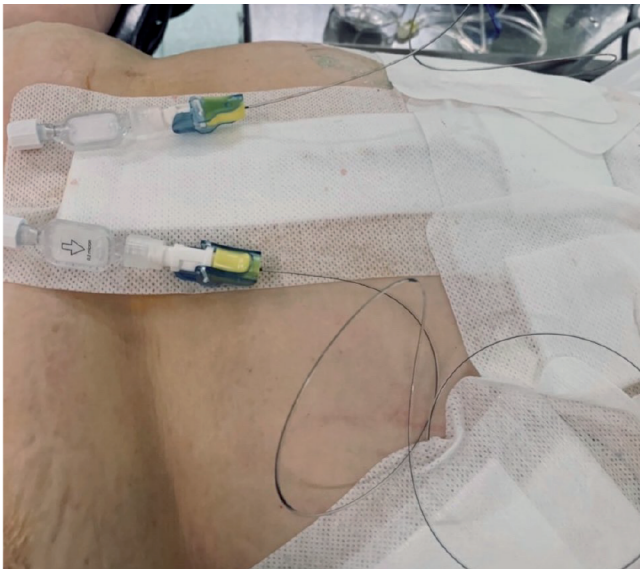

Figure 3. Bilateral catheter placement.

Study outcomes

The primary outcome was postoperative pain evaluated as the absolute value of NRS at 0, 6, 12, and 24 hours postoperatively. Secondary outcomes were the need for opioid analgesia, incidence of mild adverse effects (*i.e.*, nausea, vomiting, and incorrect catheter placement), hemodynamic stability, and impact of different regional anesthesia techniques, quality, and patients' satisfaction regarding the postoperative course (Likert scale).

Statistical analysis

Data were tested for normal distribution by the Shapiro-Wilk test and are expressed as mean and standard deviation (SD), mean with 95% confidence interval, or median with interquartile range 25-75 (IQR), as appropriate. Data analysis was performed for parametric variables with a test for independent samples. Kruskal-Wallis nonparametric analysis of variance (ANOVA) was used for nonparametric continuous variables. Categorical variables were analyzed with chi-squared or Fisher's exact test, as appropriate. Regarding hemodynamic stability, a repeated measures analysis of variance was performed using the R package (Bates *et al.* 2015).

Statistical analyses were performed using statistical software R (R Core Team, 2018) and associated statistical libraries. A p-value <0.05 was considered statistically significant.

Results

During the study period, 40 consecutive patients were evaluated for eligibility. Nine patients were excluded: eight denied consent, and one because of a history of opioid dependence. Thirty-one patients were enrolled in a ten-month period. After data collection, 15 patients were assigned *post hoc* to the TEA group, and 16 patients to the TAP group. The baseline characteristics of the patients are presented in Table 1. There were no statistical differences between the two groups.

Table 1. Characteristics of the patients.

Variables	Overall (n=31)	TEA group (n=15)	CTAP group (n=16)	p-value
Age (years)	64.39±12.53	65.27±12.48	63.56±12.94	0.71
Gender (M/F)	15/16	6/9	9/7	0.69
Weight (kg)	75.32±15.34	73.87±15.46	76.69±15.60	0.61
Height (cm)	165.16±8.94	163.60±9.47	166.63±8.46	0.35
ASA	3 (2-3)	3 (2-3)	3 (2-3)	0.62

TEA, thoracic epidural analgesia; CTAP, continuous transversus abdominis plane; ASA, American Society of Anesthesiologists.

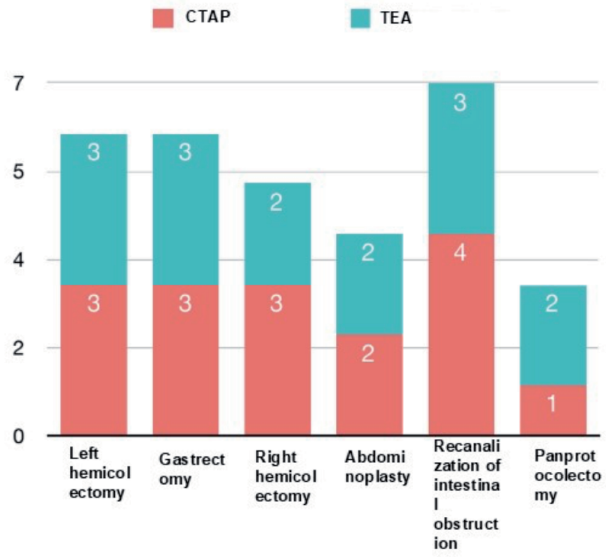

Figure 4. Different types of surgery and distribution in both groups. CTAP, continuous transversus abdominis plane; TEA, thoracic epidural analgesia.

Of the 31 patients included, 7 underwent intestinal recanalization surgery, 5 had right colon resections, 6 underwent radical gastrectomies, 6 had left colon resections, 4 had abdominal wall plastic surgeries for median laparoceles, and 3 underwent pancolectomy. All procedures were performed using a laparotomic approach (Figure 4).

Outcome measures are summarized in Table 2.

No significant differences were observed in NRS values at 0, 6, 12, and 24 hours between groups.

Only 3 patients in the TAP group required opioids in the first 24 hours; however, no differences were observed in median opioid consumption between groups (TEA 0.00 [0.00-0.00]; TAP 0.00 [0.00-0.00], p=0.08).

Hemodynamic stability was evaluated using mean arterial pressure and heart rate values, with no significant differences found for either parameter over time (Figure 5). The incidence of PONV was similar in both groups (p=0.47).

Likert scale scores were 5.00 (4.25-5.00) in the TAP group and 4.00 (4.00-5.00) in the TEA group, p=0.06.

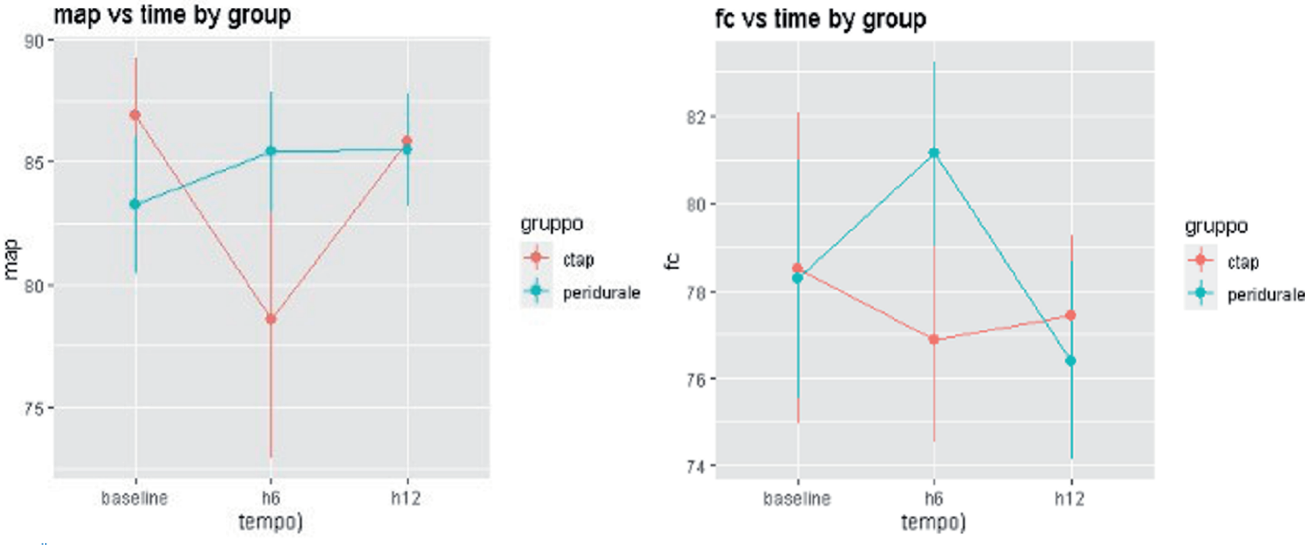

Figure 5. MAP (mean arterial pressure) and cardiac frequency *vs.* time in both groups.

Table 2. Outcome measures.

Variables	Overall (n=31)	TEA group (n=15)	CTAP group (n=16)	p-value
NRS 0 h	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.75)	0.82
NRS 6 h	2.00 (1.00-3.00)	2.00 (1.00-3.00)	1.00 (1.00-2.00)	0.09
NRS 12 h	1.00 (1.00-2.00)	1.00 (1.00-2.00)	2.00 (1.00-2.75)	0.10
NRS 24 h	1.00 (1.00-1.00)	1.00 (1.00-1.00)	1.00 (1.00-1.00)	0.64
Opioids consumption 24 h (mcg)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.08
Need for rescue (No/Yes, number of patients)	28/3	15/0	13/3	0.22
PONV (No/Yes, number of patients)	19/12	8/7	11/5	0.47
Satisfaction	5.00 (4.00-5.00)	4.00 (4.00-5.00)	5.00 (4.25-5.00)	0.06

TEA, thoracic epidural analgesia; CTAP, continuous transversus abdominis plane; NRS, number rating scale; PONV, postoperative nausea and vomiting.

Discussion

The main finding of this prospective, observational study is that both TAP and TEA are able to guarantee good-quality analgesia with low opioid consumption in patients undergoing major abdominal surgery performed through a laparotomic approach. No differences were observed in NRS scores and opioid consumption during the first 24 postoperative hours. Additionally, it is notable that the median NRS scores remained below 2.0 in both groups, indicating good pain management. Patient satisfaction scores were similar or slightly higher in the TAP group, probably due to the greater comfort offered by catheters placed in the transversus abdominis plane compared to the epidural catheter. Two patients in the TAP group required a double dose of sublingual sufentanil in the postoperative period, while one patient received a single dose; none of the patients in the epidural group required opioids postoperatively. This suggests that opioid consumption in the postoperative period was limited.

One of the most significant clinical implications is the superior safety profile of TAP blocks. TEA is known for its efficacy but also its association with complications such as hypotension, urinary retention, motor block, and technical difficulties, especially in patients with spinal abnormalities, coagulopathies, or infection risk at the catheter insertion site.[10] In contrast, TAP blocks offer a simpler and safer approach, especially when performed under ultrasound guidance, which significantly reduces the risk of inadvertent organ puncture and ensures accurate deposition of local anesthetic between the internal oblique and transversus abdominis muscles.[11]

Another key advantage observed with TAP blocks was the higher patient satisfaction, which may stem from reduced invasiveness, lower discomfort during catheter management, and better mobility. This is consistent with ERAS principles, where early ambulation is emphasized to reduce postoperative complications like thromboembolism and pulmonary issues.[12] Since TAP blocks do not induce motor block, they enable quicker mobilization compared to TEA.

However, TAP blocks also have limitations. Unlike TEA, which can provide visceral analgesia due to its central neuraxial mechanism, TAP blocks are limited to somatic pain control of the anterior abdominal wall. This means that for surgeries involving significant visceral manipulation or deeper abdominal procedures, supplementary analgesia may still be necessary.[13] In our cohort, this limitation may explain why a few patients in the TAP group required rescue opioid administration.

Interestingly, six patients in the TAP group had received a preoperative single-shot TAP block, which could have provided better intraoperative pain control. Though the small sample size precluded statistical analysis, this subgroup represents a valuable direction for further research. The combination of preoperative and continuous postoperative TAP block may enhance analgesic continuity and reduce intraoperative opioid demand.

Moreover, since the TAP block primarily provides somatic analgesia and its efficacy relies heavily on the spread within interfascial planes, alternative approaches such as the ultrasound-guided quadratus lumborum block (QLB) have been proposed to improve outcomes. Prospective studies comparing QLB and TAP blocks suggest that QLB provides broader and longer-lasting analgesia.[14] Recently, a dynamic injection technique during fascial blocks has been proposed as a novel strategy to enhance local anesthetic distribution, reduce dosage, and improve block efficacy by targeting a wider number of dermatomes. In this way, a dynamic TAP block can be performed, advancing the needle progressively within the target fascial plane to favor posterior spread of local anesthetic, reaching the anterior surface of the quadratus lumborum muscle.[15]

In terms of hemodynamic stability, our study showed no significant fluctuations in mean arterial pressure or heart rate across both groups, affirming the cardiovascular neutrality of both techniques when used in a controlled perioperative setting. Nevertheless, the absence of hypotensive episodes in the TAP group aligns with existing literature and reinforces its utility in patients at risk of hemodynamic compromise.[16]

The incidence of PONV did not differ significantly between the two groups, supporting the hypothesis that PONV may be more closely related to the surgical procedure, patient characteristics, and anesthetic agents used, rather than the analgesic technique alone.[17]

While our findings are supported by similar studies, such as those by Regmi *et al.*[18] and Kadam & Howell,[19] it is worth noting that some trials report divergent outcomes, often attributable to differences in technique standardization, local anesthetic concentration, and patient populations. For instance, Kandi *et al.*[20] found lower opioid consumption in the TAP group but acknowledged limitations in sample size and statistical power.

While intravenous adjuvants such as dexamethasone have been shown to prolong the duration of postoperative analgesia and are considered a useful component of multimodal pain management,[21,22] we believe they should not be viewed as a replacement for continuous regional techniques in the context of major open abdominal surgery. In our patient population, the use of TAP catheters allowed for continuous, site-specific analgesia over the critical first 72 hours postoperatively, contributing to better pain control and potentially facilitating earlier mobilization and recovery. Given the intensity and invasiveness of the surgical procedure, the placement of a perineural catheter remains, in our view, the most appropriate and effective strategy for ensuring adequate and sustained analgesia.

Ultimately, the continuous subcostal TAP block represents a compelling analgesic modality that aligns with modern perioperative care philosophies. It allows effective pain management with minimal systemic side effects, promotes early mobilization, and is generally more accessible and feasible across diverse healthcare settings due to the wider availability of ultrasound guidance.

However, larger randomized controlled trials with standardized dosing protocols and inclusion of multimodal analgesic adjuncts are necessary to confirm these findings and refine the indications for TAP blocks *versus* epidural analgesia. Additionally, research should aim to stratify patients by surgical procedure type and visceral involvement to better predict which patient groups will benefit most from either technique.

Conclusions

Continuous bilateral subcostal TAP block is a safe and effective technique for managing postoperative pain following major abdominal surgery. Its use aligns with ERAS principles, especially in patients contraindicated for TEA. Given its ease of administration, favorable safety profile, and patient comfort, TAP block should be considered a valuable alternative in multimodal analgesic strategies.

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