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ABDOMINAL RADIOLOGY

Role of paravertebral block anaesthesia during percutaneous transhepatic thermoablation

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Abstract

Purpose This paper discusses the technique and preliminary results of right thoracic paravertebral block (TPVB) for percutaneous thermal ablation of liver tumours.

Materials and methods Between October 2011 and August 2012 we treated 36 lesions (25 hepatocellular carcinoma and 11 metastases) in 30 patients aged 47–85 years (mean 67.5). Patients received ultrasound (US)-guided injection of 7 ml of naropin 0.75 % in T7, T9 and T11 levels, below the costo-vertebral ligament, until we observed an anterior displacement of the parietal pleura. For the subcapsular lesions, a cervical right phrenic nerve block was associated. The level of analgesia was evaluated during and after the percutaneous procedures with the Numerical Rating Scale. Finally, we investigated statistical correlations between pain and lesions (histological type, site, dimensions), and ablation time and technique (microwave or radiofrequency ablation).

Results Technical success was achieved in all patients. Despite the correct anaesthetic diffusion during the ablation, 10 patients (33.3 %) reported medium/severe pain and intravenous sedation was required. Pain was not found to correlate with any variable. No complications were observed.

Conclusions In most cases, TPVB is a safe and effective technique for conscious anaesthesia during percutaneous thermal ablation of liver tumours. Failures probably derive from left sympathetic and parasympathetic fibre stimulation. We recommend performing a TPVB in the presence of the anaesthetist.

Keywords Paravertebral block · Percutaneous thermal ablation · Liver tumours

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Introduction

Coagulative necrosis, induced by the percutaneous ablation of liver tumours, can cause intense pain both during the procedure and in the following hours, particularly in presence of subcapsular nodules [1]. "Conventional" analgesia includes, in addition to local anaesthesia with hydrochloride lidocaine, intravenous infusion of remifentanil and midazolam [2]; however, a significant number of patients experience severe pain especially in the following 24 h. Moreover, in some patients with associated comorbidities (heart disease, lung disease and hepatorenal impairment), intravenous infusion of these drugs can be difficult to manage in the ultrasound unit due to the possible occurrence of complications (hypotension and respiratory depression) [2]. Some centres proposed epidural anaesthesia as an alternative anaesthesiological option, which was not, however, widely adopted considering the risk of possible neurological complications [3].

Recently, several reports have described the possibility of obtaining a safe, effective and prolonged locoregional analgesia using a thoracic paravertebral block (TPVB). This consists of an injection of local anaesthetic at the emergence of the spinal nerves from the thoracic intervertebral foramina, ipsilateral to the tumour. It induces a sympathetic block, involving multiple contiguous dermatomes above and below the injection site [4–10]. This technique was performed for the first time in 1905 by Hugo Sellheim of Leipzig [11–13]. Detailed anatomical knowledge is required [7]; furthermore, we believe ultrasound (US) guidance can be useful, even though no reports about its effect are present in the literature.

The purpose of this paper was to critically report and discuss the results of our preliminary experience with analgesia by means of a unilateral visceral somatic block in patients undergoing percutaneous thermal ablation of hepatic nodules.

Materials and methods

Patients

Between October 2011 and August 2012, a total of 30 patients (24 males and 6 females aged between 47 and 85 years, mean age 67.5 years) undergoing percutaneous ablation of 36 primary or secondary liver tumours by radiofrequency (RFA, 24 nodules) or microwave (MWA, 12 nodules) were given a right paravertebral block prior to the procedure.

More precisely, 21 patients had hepatocellular carcinoma (HCC), whereas in 9 cases lesions from metastatic colorectal carcinoma (MTS) were present. All HCC had developed on cirrhotic livers (three HBV, seven HCV, four alcoholic, one HBV + HCV and six cryptogenic). Seventeen patients had a single neoplasia, while four patients had a bifocal cancer. As for the MTS, eight patients had a single node metastasis, whereas one patient had trifocal disease.

The patients' body weight was between 48 and 105 kg (mean 77.8 kg) and the body mass index (BMI) was between 21.33 and 33.89 kg/m^2 with an average value of 27.12 kg/m^2. In our cohort, 17 patients belonged to class II of the American Society of Anaesthesiologists (ASA) and 13 patients in class III. The treated patients had platelet counts ranging from 261,000 to 41,000/mm^3 (average value 143,000/mm^3) and INR between 1.73 and 0.96 (average 1.18).

Exclusion criteria were chronic pain, regular use of analgesics, severe rib cage deformities or allergies to local anaesthetics. Patients comorbidities are presented in Table 1.

Table 1 Patient comorbidities

Comorbidities	
Hypertension	22 patients
Diabetes	17 patients
Chronic obstructive pulmonary disease (COPD)	11 patients
Previous acute myocardial infarction	5 patients
Arrhythmia	3 patients
Obesity	8 patients

Table 2 Patients with single nodule

	Lesions	
	Central	Subcapsular
HCC nodules	7	10
MTS nodules	3	5
Total	10	15

HCC hepatocellular carcinoma, *MTS* metastasis

Table 3 Patients with multiple nodules

	Lesions	
	Central	Subcapsular
HCC nodules	6	2
MTS nodules	3	–
Total	9	2

HCC hepatocellular carcinoma, *MTS* metastasis

Lesion characteristics

The HCC nodules had a diameter between 1.1 and 5.1 cm (mean 2.78 cm), while the size of MTS was between 1 and 5.5 cm (mean 2.89 cm). Lesions were distinguished into parenchymal, more than 10 mm away from the capsule surface and subcapsular (Tables 2, 3).

Procedure

The day before the procedure all patients gave written informed consent for the anaesthesiological protocol. In the US suite, after cannulation of the radial vein, the vital parameters were monitored (electrocardiogram, pulse oximetry and blood pressure).

The patient was positioned with the back facing the two operators: a radiologist and an anaesthetist. Spinous and transverse processes of the thoracic vertebrae between T6 and T10 were identified using US guidance and palpation by hand. After skin disinfection, local anaesthesia with 2 ml of 2 % lidocaine was administered for each metamer.

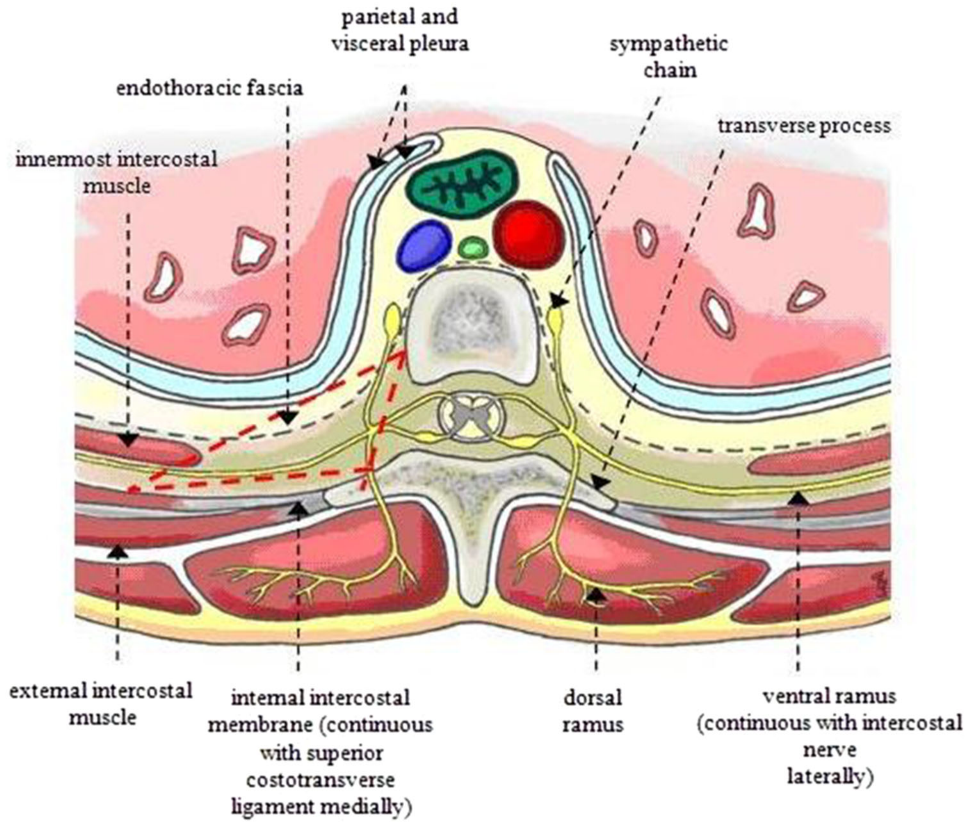


Fig. 1 Anatomical relationships of a right paravertebral thoracic space (*dotted line*)

Fig. 2 Ultrasound-guided location of a right paravertebral thoracic space

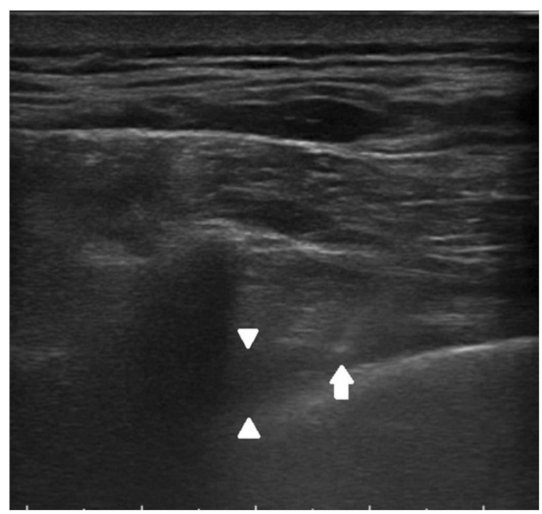


Fig. 3 The tip of the needle (*arrow*) reaches the paravertebral space (*head arrow*)

Using a 4- to 13-MHz multifrequency linear probe pre-set to soft tissues (Esaote, Genoa, Italy), the needle was inserted along the paravertebral soft tissues with an inclination of 45° to reach the transverse process (Fig. 1); once the correct position of the needle tip had been demonstrated (Fig. 2), absence of aspiration of blood or cerebrospinal fluid (CSF) confirmed that no vessels or dural sac had been damaged. After that, 7 ml of naropin 0.75 % was inoculated within each right paravertebral space between T6 and T10. The anaesthetic was slowly injected at the emergence of the column of sensory nerve roots, just below the costovertebral ligament, to visualise the parietal pleura detachment (Figs. 3, 4). The correct diffusion of the drug was confirmed by the absence of significant resistance to

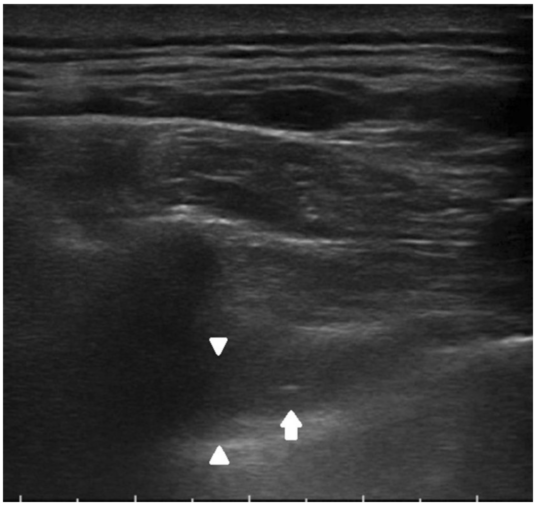


Fig. 4 The anaesthetic injection causes the displacement of the parietal pleura (*arrow*) with the expansion of the paravertebral space (*arrow head*)

injection. A 22-G, 10-cm-long Pajunk needle was used, which is particularly echogenic, very sharp and sufficiently rigid. Once the TPVB was obtained, the patient was placed supine. In patients with subcapsular lesions, an additional right phrenic nerve block was performed; with the patient's head turned to the left, the cervical segment of the phrenic nerve was located next to the anterior scalene muscle under US guidance, and was anaesthetised with 3 cc of 2 % lidocaine.

A skin landmark was placed for the insertion of the thermal ablation needle; at that level, local anaesthesia with 10 ml of carbocaine was performed. An expandable (with curved, deployable tines ranging from 3 to 5 cm) needle electrode (Med Italia, Medolla, Italy) was used to perform, for each lesion, two successive cycles between 80 and 190 W, for a total duration of 20–45 min, reaching a temperature of 105 °C.

As for the microwave technique (MW) (Covidien, Dublin, Ireland and HS Amica, Aprilia, Latina, Italy), several cycles were performed: power varied between 45 and 80 W for 10–20 min, reaching an intratumoral temperature of 180 °C.

Hypotension, defined as a decrease in systolic blood pressure >30 % from baseline, was treated with intravenous fluid infusion. In order to maintain a plasma saturation ≥96 %, oxygen was administered via a face mask, if needed.

During the procedure, the type and severity of the pain experienced by the patient were carefully assessed and recorded using a verbal numerical rating scale (NRS, 0 no pain, 10 worst pain imaginable), which was used to quantify the pain both during the procedure and in the following 24 h. We distinguished pain into the following three categories: mild pain (NRS between 1 and 2), moderate pain (NRS between 3 and 6) and severe pain (NRS between 7 and 10). If the patient reported an NRS score >2, intravenous remifentanil and propofol was administered in the course of the procedure and a therapy with paracetamol (1 g every 8 h) and tramadol (1 vial as required for the next 24 h) was recommended.

Statistical analysis

Possible correlations between pain and thermal ablation were evaluated. Moreover, the following features were analysed: lesion site, number and histology of liver nodules, duration of the procedure and type of technique used. The analysis was carried out by applying descriptive statistical methods. In order to describe the relationship between the variables, linear correlation with Pearson's *r* coefficient was used. The correlation coefficient is standardised: it can have values ranging from −1.00 (perfect negative correlation) to +1.00 (perfect positive correlation). Zero indicates a lack of relationship between the two variables. Correlation does not imply the concept of cause and effect, but only the existence of a relationship between the variables.

Results

Technical success was obtained in all of the 30 patients treated with TPVB (including those 10 cases with associated cervical block of the ipsilateral phrenic nerve). Technical success was defined as the correct positioning of the needle and US demonstration of the spread of the anaesthetic in the subpleural spaces.

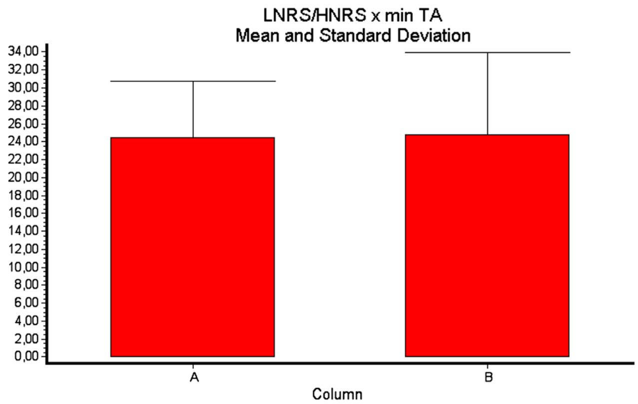
In 20/30 patients (66.6 %), a satisfactory analgesia (NRS $\leq$ 2) was obtained during ablation. In 10/30 cases (33.3 %), the patient reported burning pain (NRS > 2), which required an increase in infusion speed of remifentanil (from 0.03 up to a maximum of 0.08 γ/kg/min) in combination with administration of midazolam and acetaminophen (1 g every 8 h) and tramadol (1 vial as needed every 5 h) in the following 24 h. Three patients (10 %) reported a medium pain intensity (NRS 3–6), while seven patients (23.3 %) experienced severe pain (NRS 7–10). Pain irradiation was visceral, sometimes accompanied by nausea (5/10), epigastric (1/10) and right shoulder pain (4/10). Five patients (16.6 %), in whom the paravertebral block was effective during thermal ablation, reported pain (NRS > 2) in the following hours and were therefore treated with tramadol. There were no major complications; one patient reported a small subcutaneous haematoma.

During the study, considering the progressive optimisation of the technique, we obtained a reduction in time

Table 4 Relationship between pain and ablation period

Group A: NRS < or = 2	20 patients
Group B: NRS > 2	10 patients

NRS numerical rating scale



- Group A (NRS ≤2) : mean value 24.4, median 25
- Group B (NRS >2) : mean value 24.8, median 20

required to perform TPVB; the average time was 11 min (range 8–17 min).

No statistically significant correlations were demonstrated between pain and duration of ablation, ablation technique used, site, histological type and number of lesions (Table 4, Figs. 5, 6, 7, 8). It may be noted, however, that lesion histology and number are the variables most closely related to the onset of pain.

Discussion

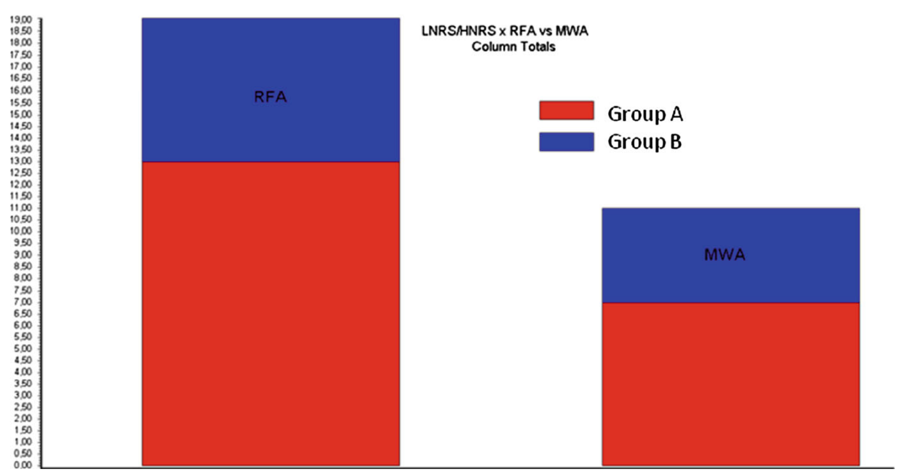
Only two experiences are reported in literature on the use of TPVB during hepatic ablation procedures: Ning et al. in 2011 [7], who prospectively evaluated 20 patients with primary and secondary liver lesions treated with radiofrequency, and a case report published by Culp et al. [8] of a patient with carcinoid liver metastases. The technique used in these reports was similar, but without the US guidance used by us. In fact, in our experience, the block was performed by radiologists highly experienced in US, whereas

Fig. 5 **a**, **b** Relationship between pain and technique

(a)

	RFA	MWA
Group A: NRS < or =2	13 patients	7 patients
Group B: NRS>2	6 patients	4 patients

NRS, numerical rating scale; *RFA*, radiofrequency ablation; *MWA*, microwave ablation.



(b)

	NRS≤2	NRS>2
MWA	-0.048	0.048
RFA	0.048	-0.048

in the Chinese experience and Culp's case report, the operator was an anaesthetist. The metameric levels treated were the same (T6–T10), as was the drug used (ropivacaine). In Ning's report, there were no major complications, only a single case of vasovagal reaction treated with intravenous ephedrine and fluids. In our experience, we only recorded one case of minor complication (haematoma) which resolved spontaneously. In effect, this technique is less invasive than the epidural option because it does not need direct access to the medullary canal: this explains the negligible rate of minor complications also reported in previous studies, in which the paravertebral block was performed for different objectives (multiple rib fractures, traumatic liver lesions, chronic pain, etc.). The average complication rate reported in the literature varies between 2.6 and 5 % [14, 15]: the most common reported complications are hypotension (4.6 %), haematoma due to the accidental puncture of vessels (3.8 %), pleural lesions (1.1 %) and pneumothorax (0.5 %). In particular, a vasovagal reaction can be related to an accidental migration of the anaesthetic into the epidural space: therefore, we believe that the use of US can be very useful for identifying the paravertebral space, guiding for percutaneous puncture and controlling for the distribution of the anaesthetic. In fact, in our experience we have seen accidental epidural migration of the drug, which can cause anaesthesia and motor deficit in the lower limbs in addition to a vasovagal reaction.

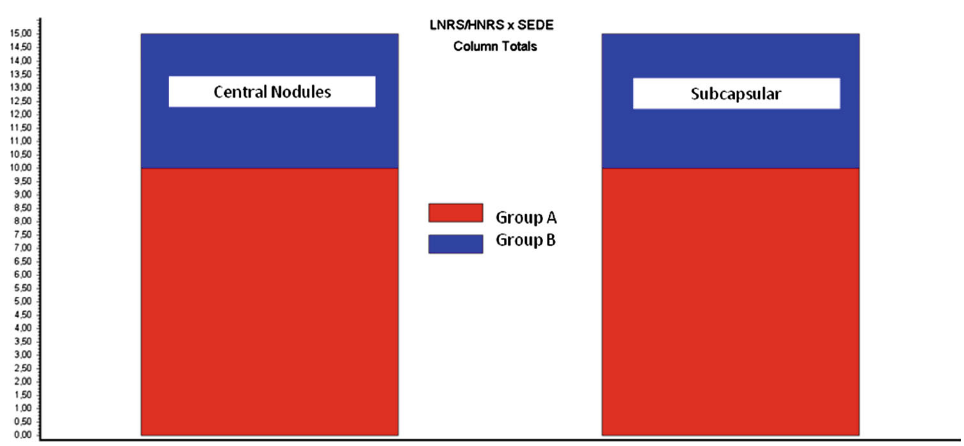
For the evaluation of results, we adopted the same rating scale as used by Ning (NRS) and established a precise cut-off value (NRS 2) to evaluate the effectiveness of analgesia, considering, with this very restrictive criterion, values above this limit as a treatment failure. Using this criterion, we recorded a 66.6 % clinical success. Ning, conversely, reported an average pain level of 5 (NRS) during the procedure. Moreover, the comparison of results is complicated by the fact that half of the patients treated in the Chinese experience (10/20) was sedated with propofol during the procedure. However, if we consider only the cases of severe pain (NRS > 7), our percentage is higher (23.3 vs 10 %). It is important to remember that our series is larger (30 vs. 20 patients), the mean volume of liver lesions is greater (2.8 cm for HCC, 2.9 cm for MTS vs. 2.4 in Ning) and that, in our experience, the microwave

Fig. 6 **a**, **b** Relationship between pain and lesion site

(a)

	Central	Subcapsular
Group A: NRS < or =2	10 Patients	10 Patients
Group B: NRS>2	5 Patients	5 Patients

NRS, numerical rating scale



(b)

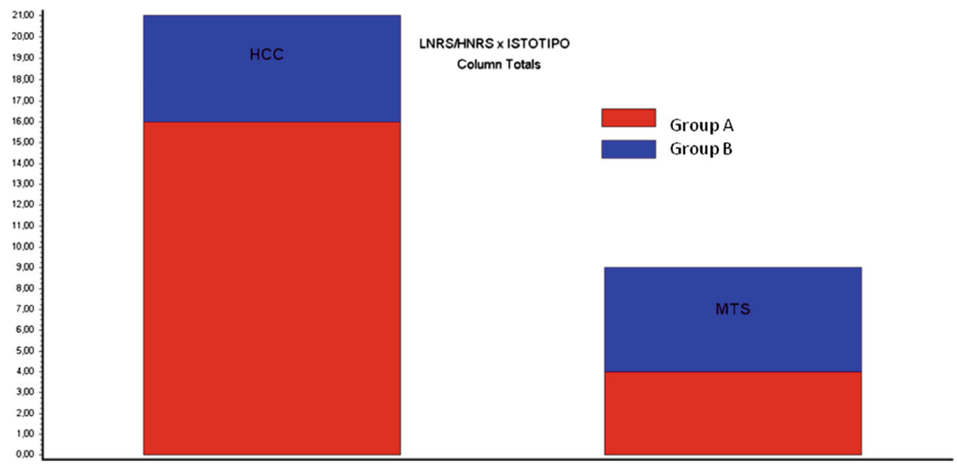
	NRS≤2	NRS>2
Central nodules	0.051	-0.051
Subcapsular nodules	-0.051	0.051

Fig. 7 **a**, **b** Relationship between pain and histotype (HCC vs MTS)

(a)

	HCC	MTS
Group A: NRS < or =2	16 patients	4 patients
Group B: NRS>2	5 patients	5 patients

HCC, hepatocellular carcinoma; *MTS*, metastasis; *NRS*, numerical rating scale.



(b)

	NRS≤2	NRS>2
HCC	0.308	-0.308
MTS	-0.308	0.308

technique was used for larger lesions (whereas Ning reported the exclusive use of RFA). Ning also reported using a multiple injection technique, as done in other experiences reported in the literature about vertebral blocks performed for other reasons [15, 16]: Ning emphasises the importance of this technique in pain control, suggesting that it may also be responsible for the high rate (35 %) of contralateral blocks in his experience, much higher than the previously reported rates of 20 [15] and 1.1 % [16].

In our experience, complete technical success is based on the US evaluation: in all cases, the correct spread of the anaesthetic with pleural detachment was always demonstrated. The cases of clinical failure of the vertebral block were therefore unexpected and not explainable by technical errors. In this sense, no possible explanations are reported by Ning. From our point of view, the most likely hypothesis is that the diffuse visceral pain reported by some patients is due to the stimulation of left sympathetic fibres and vagal fibres; the liver presents in fact a dual innervation: both orthosympathetic (from the seventh to tenth thoracic segment of the spinal cord, which reaches the liver through the splanchnic nerves and the celiac plexus) and parasympathetic [17]. This could be a limit of the unilateral vertebral block, even if the high rate of contralateral "unexpected" block reported by Ning represents an interesting matter.

Unlike Ning, we tried to correlate the pain sensation to the different characteristics of the patients: analysis of the data showed no statistically significant relationship between the variables considered (procedure duration, technique, location, number and histology of the lesions) and pain onset. The most significant relationship, however, was between lesion number and histology: considering these results, we can hypothesise that patients with multiple metastases are less responsive to the vertebral block and consequently good candidates for alternative forms of analgesia or additional therapies.

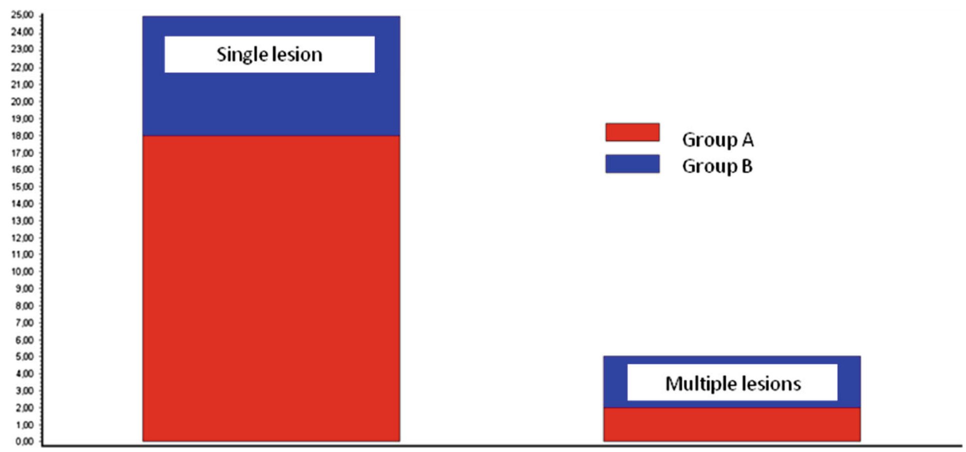
In view of the absence of factors that can unequivocally be related to the ineffectiveness of the treatment, we hope to develop as soon as possible a block efficacy test to be used before the ablation procedure.

Fig. 8 **a**, **b** Relationship between pain and lesion number

(a)

	Single lesion	Multiple lesions
Group A: NRS < or =2	18 patients	2 patients
Group B: NRS>2	7 patients	3 patients

NRS, numerical rating scale.



(b)

	NRS≤2	NRS>2
HCC	0.252	-0.252
MTS	-0.252	0.252

HCC, hepatocellular carcinoma; *MTS*, metastasis; *NRS*, numerical rating scale.

However, we believe that our study, designed and conducted in collaboration with the anaesthetists of our Interventional Radiology Unit, confirms the results of Ning's experience, highlighting the versatility, potentiality and advantages of paravertebral block, during algogenic treatments such as percutaneous hepatic ablation. This is a pilot study based on respect for the desires of each patient, who were adequately informed of the benefits, possible ineffectiveness and complications of the paravertebral block, assuring intravenous analgesia if needed.

These results have led us to design a prospective randomised two-arm study (vertebral block vs intravenous analgesia), for which we have already requested the approval of the hospital ethics committee. In fact, we believe that the paravertebral block technique could be extended to other interventional radiology procedures, and especially to liver and biliary procedures such as percutaneous biliary drainage, as already reported in the literature [18, 19], portal embolisation, transjugular intrahepatic portosystemic shunt.

Theoretically, this technique could be managed independently by the radiologist because naropin is a common anaesthetic that does not require the presence of the anaesthetist for its management. However, our long and effective collaboration with anaesthetists suggests that a multidisciplinary management is essential, because of the possible need for intravenous analgesia.

Conclusions

The thoracic paravertebral block is a well-tolerated and safe technique for the anaesthesia of patients undergoing percutaneous thermal ablation of malignant liver tumours. The technique is promising and may be feasible for other interventional radiological procedures. Despite proper technical execution, we reported clinical failures in some cases: a predictive test will be able to select patients that are not responsive to the vertebral block for several conditions. Although the somatic block can be performed by any specialist, we suggest collaborating together with an anaesthetist, especially in consideration of the pain assessment during the procedure and the possible need for intravenous therapy.

Conflict of interest Carlo Gazzera, Paolo Fonio, Riccardo Faletti, Maria Chiara Dotto, Fabio Gobbi, Pierpaolo Donadio, Giovanni Gandini declare no conflict of interest.

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