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## PAIN

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# Single-injection thoracic paravertebral block for postoperative pain treatment after thoracoscopic surgery<sup>†</sup>

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**Background.** Thoracoscopic surgery can be associated with considerable postoperative pain. While the benefits of paravertebral block on pain after thoracotomy have been demonstrated, no investigations on the effects of paravertebral block on pain after thoracoscopy have been conducted. We tested the hypothesis that a single-injection thoracic paravertebral block, performed preoperatively, reduces pain scores after thoracoscopic surgery.

**Methods.** Of 45 patients recruited, 40 completed the study. They were randomly allocated to two groups: the paravertebral group received i.v. patient-controlled analgesia (PCA) with morphine plus single-injection thoracic paravertebral block with bupivacaine 0.375% and adrenaline 1:200 000 0.4 ml kg<sup>-1</sup> (n=20). The control group was treated with a back puncture without injection and morphine PCA (n=20).

**Results.** The main outcomes recorded during 48 h after surgery were pain scores using the visual analogue scale (VAS, 0–100). Secondary outcomes were cumulative morphine consumption and peak expiratory flow rate (PEFR). Half an hour and 24 h after surgery, median (25th–75th percentiles) VAS on coughing in the paravertebral group was 31.0 (20.0–55.0) and 30.5 (17.5–40.0) respectively and in the control group it was 70.0 (30.0–100.0) and 50.0 (25.0–75.0) respectively. The difference between the groups over the whole observation period was statistically significant ( $P<0.05$ ). Twenty-four and 48 h after surgery, median (25th–75th percentiles) cumulative morphine consumption (mg) was 49.0 (38.3–87.0) and 69.3 (38.8–118.5) respectively in the paravertebral group and 51.2 (36.0–84.1) and 78.1 (38.4–93.1) in the control group (statistically not significant). No differences were found in PEFR or the incidence of any side-effects between groups.

**Conclusion.** We conclude that single-shot preoperative paravertebral block improves postoperative pain treatment after thoracoscopic surgery in a clinically significant fashion.

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In the past few years video-assisted thoracoscopic surgery (VATS) has been used increasingly. Although it is considered a less invasive treatment than thoracotomy,<sup>1</sup> patients can experience moderate to severe pain, especially during the first hours after surgery.<sup>2,3</sup> Systemic opioids given with patient-controlled devices may be used after thoracic surgery<sup>4</sup> but the analgesic effect can be limited and undesirable side-effects may occur.<sup>5</sup> Epidural analgesia is highly effective in

relieving pain and promoting recovery of pulmonary function after thoracotomy.<sup>6–9</sup> However, it carries the risk of dural puncture, nerve lesions<sup>10</sup> and hypotension.<sup>9</sup> Thoracic paravertebral analgesia is used for surgical procedures of the thorax and the upper abdomen. Its effectiveness has been shown to be equal or even superior to that of epidural analgesia

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<sup>†</sup>This article is accompanied by the Editorial.

for post-thoracotomy pain.<sup>11–14</sup> In experienced hands this block can be performed safely and effectively. Its failure rate of 10% is comparable to that reported for epidural analgesia.<sup>14</sup> In one investigation the effect of continuous intra- and postoperative paravertebral block after VATS was evaluated in nine patients, but the study did not include a control group.<sup>15</sup>

In this double-blind, prospective, randomized trial we tested the hypothesis that a single-injection thoracic paravertebral block reduces pain scores at coughing during the first 48 h after thoracoscopic surgery in patients receiving i.v. patient-controlled analgesia (PCA) with morphine.

## Methods

The local ethics committee approved the study. The exclusion criteria were: any contraindication to paravertebral block or to the use of bupivacaine, morphine or paracetamol; age <18 yr; lack of patient's cooperation; and the daily use of opioid for more than 1 week.

The sample size required was calculated choosing a difference of 25 mm in VAS as the minimum desired difference between the groups. Setting  $\alpha=0.05$ , assuming a standard deviation of 20 mm (observed in a previous study on thoracotomy pain)<sup>16</sup> and investigating 17 subjects per group, one can detect a significant difference of 25 mm with a power of 0.8 (two-sided hypothesis). We decided to analyse 20 patients per group to minimize the chance of insufficient power, in case the observed variability was higher than expected. When protocol violations occurred the patient was excluded and another recruited. All patients gave written informed consent.

### Anaesthetic procedure

Patients were premedicated orally with midazolam 7.5 mg, 20–30 min before anaesthesia. The patients were monitored using an electrocardiogram, non-invasive arterial blood pressure device (one measurement every 5 min), pulse oximeter and Bispectral Index™ (BIS™) monitor (Aspect Medical Systems, Leiden, The Netherlands).

Anaesthesia was conducted using a total i.v. technique consisting of a target-controlled infusion of propofol using a Diprifusor™ Graseby 3500 (Graseby Medical, Watford, UK), remifentanyl infusion, vecuronium and fentanyl. Endobronchial intubation was performed with a left-sided double-lumen tube. Target BIS values were set between 30 and 50.

After induction of general anaesthesia, randomization was performed as follows: in a blind fashion a green or red cube was drawn from a small bag. When a green cube was drawn the patient was allocated to the paravertebral group. When a red cube was drawn the patient was allocated to the control group. The group allocation was stratified according to gender.

After positioning patients in the lateral position for the operation, patients in the paravertebral block group received a single-injection thoracic paravertebral block.<sup>17</sup> The upper

edge of the spinous process of the fifth thoracic vertebral body was identified by counting down from the seventh cervical body. With an epidural needle (Tuohy 18 G; Braun, Melsungen, Germany) the injection point was identified 3 cm lateral to the midline. The transverse process of the sixth thoracic vertebra was contacted. The paravertebral space was punctured by advancing the Tuohy needle over the superior border of the transverse process. After identification of the paravertebral space using a loss of resistance technique, a mixture containing bupivacaine (3.75 mg ml<sup>-1</sup>) and epinephrine (1:200 000), 0.4 ml kg<sup>-1</sup>, was injected. In the control group, the skin was penetrated 1 cm with a Tuohy needle at the same site as in the paravertebral group, but no drug was injected.

Approximately 30 min before the end of surgery, all patients received morphine 0.1 mg kg<sup>-1</sup> i.v. with a morphine PCA pump (Pharmacia, Deltec SIMS, MN, USA) and proparacetamol 2 g i.v.

### Postoperative management

All patients left the operating room with a morphine PCA pump. The pump was programmed as follows: bolus dose 1.5 mg, maximum six times per hour in the recovery room and four times per hour in the ward; lock-out interval 8 min; no background infusion. All patients received proparacetamol 2 g i.v. every 6 h until oral feeding was possible, and then paracetamol 1 g orally every 6 h for 5 days. Patients remained in the recovery room for at least 4 h or as long as indicated. Supplementary oxygen 2–4 litres min<sup>-1</sup> via nasal cannulae was administered to all patients for the first 24 h to maintain oxygen saturation greater than 93%.

Using the visual analogue pain scale (VAS; 0 mm=no pain, 100 mm=worst pain imaginable), patients were asked to rate their pain at rest and during coughing every hour after arrival in the recovery room. Adequate analgesia was defined as a VAS  $\leq 30$  mm at rest. Inadequate analgesia was defined as VAS at rest >30 mm despite proper use of patient-administered morphine. In this case, additional nurse-administered i.v. boluses of morphine 2 mg were given. If four boluses did not yield adequate analgesia ketorolac 30 mg i.v. every 8 h for a maximum time of 48 h was added.

Sedation was recorded according to the following score: 0=alert; 1=drowsy; 2=sleeping, easy to arouse verbally, does not fall asleep during or immediately after conversation; 3=sleeping, opens eyes to verbal command, falls asleep during or immediately after conversation; 4=does not open eyes to verbal command.<sup>18</sup> A maximum score of 3 during the first 12 postoperative hours or 2 during the subsequent observation period was accepted. In the presence of higher scores the PCA bolus was reduced by 0.5 mg.

In the presence of nausea, with or without vomiting, ondansetron 4 mg i.v. was given and repeated once if nausea persisted (maximum dose 8 mg per day).

Peak expiratory flow rate (PEFR) was measured using an AsmaPLAN+ peak flow meter (Vitalograph, Milton Keynes, UK). In a sitting position after maximal inspiration, the patient was requested to exhale completely as fast as possible into the peak flow meter. The mean value of three measurements was recorded.

### Data collection

The age, weight, height and ASA class of each patient was recorded, as were the type and duration of surgery and the total dose of propofol and opioid.

The following data were collected after arrival in the recovery room and 1, 2 and 3 h after surgery: pain intensity at rest and during coughing by using the VAS score; sedation score; sensory level as assessed by sensitivity to cold (gel bag); percutaneous oxygen saturation 3 min after discontinuation of supplementary oxygen (air test); and cumulative morphine consumption. Length of stay in the recovery room was also recorded. After 24 and 48 h, patients were asked by an observer blinded to the group allocation to rate pain at rest and when coughing using the VAS and to rate their overall satisfaction with pain management using the following score: 1=very unhappy, 2=unhappy, 3=happy, 4=very happy. After 24 and 48 h, PEFR and cumulative morphine consumption, including nurse-administered boluses, were recorded.

On discharge from hospital, the following data were recorded: persistent need for analgesics; total length of hospital stay after surgery; and the occurrence of any post-operative complication.

The patients and the observer who collected the postoperative data were blinded to the group allocation.

### Statistical analysis

Numerical data of the two groups were compared using the Student's *t*-test or the Mann-Whitney test, depending on whether the data were distributed normally or not. For non-Gaussian numerical data collected more than once during the study period, the two-way repeated measures analysis of variance (ANOVA) on ranks was used with time of measurement as the repeated factor and group as the non-repeated factor. Categorical data were analysed using Fisher's exact test.  $P < 0.05$  was considered significant. The statistical software used was SigmaStat for Windows version 3.0 (SPSS, Chicago, IL, USA).

## Results

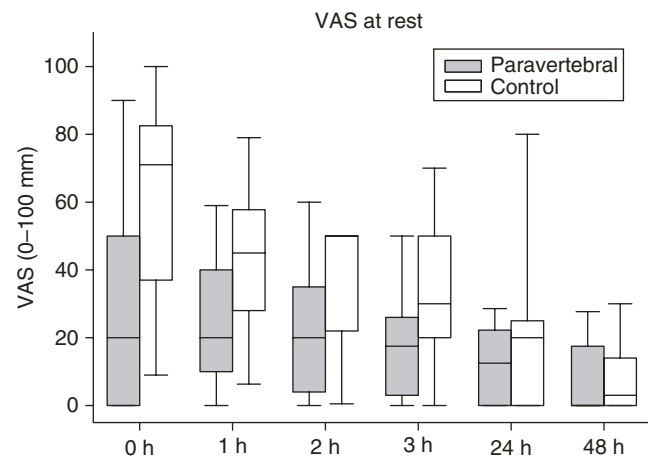
Three patients refused consent. A total of 45 patients consented to participate at the preoperative anaesthesia visit. Five patients were excluded because surgery proceeded unexpectedly to a thoracotomy ( $n=3$ ), there were signs of intravascular injection of bupivacaine with a test dose observed after two needle positionings ( $n=1$ ) and loss of the postoperative data sheet ( $n=1$ ). Thus, 40 patients were

**Table 1** Patient characteristics, duration of surgery and anaesthetic requirements in the paravertebral and control groups. Data are mean (range), mean (SD) or number of patients. n.s., not significant

	Paravertebral group	Control group	P-value
Sex (F/M)	7/13	8/12	–
Age (yr)	55.4 (19–88)	56.6 (18–84)	–
Weight (kg)	70.2 (13.4)	66.7 (12.2)	–
Height (cm)	171 (10)	171 (11)	–
ASA class (I/II/III)	3/9/8	6/7/6	–
Duration of surgery (min)	90 (57)	61 (26)	n.s.
Total amount of propofol (mg kg <sup>-1</sup> )	20.6 (8.6)	16.5 (6.8)	0.014
Total amount of fentanyl (µg kg <sup>-1</sup> )	2.3 (1.3)	3.3 (1.2)	0.037
Total amount of remifentanyl (µg kg <sup>-1</sup> )	17.4 (15.1)	13.3 (8.5)	n.s.

**Table 2** Distribution of types of video-assisted thoracoscopic surgery in the paravertebral and control groups (number of patients)

	Paravertebral group	Control group
Biopsy	7	7
Lung resection	10	6
Pleurodeses	1	5
Resection of intrathoracic tumour	2	2

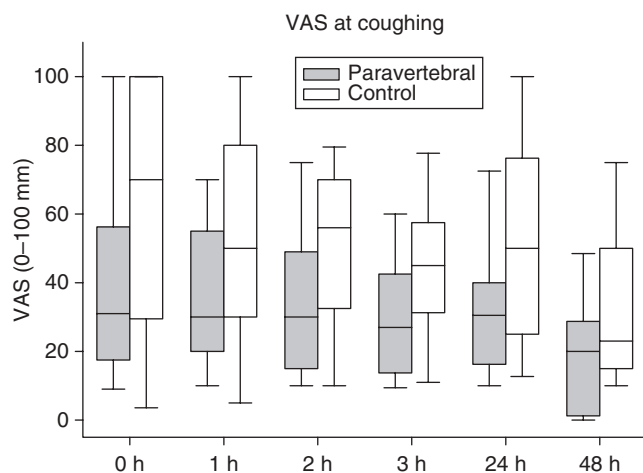


**Fig 1** Pain course during 48 h after surgery at rest. The median, interquartile range (box) and the 5th and 95th centiles are shown. The difference between the groups was statistically significant ( $P < 0.05$ ; two-way repeated measures ANOVA on ranks).

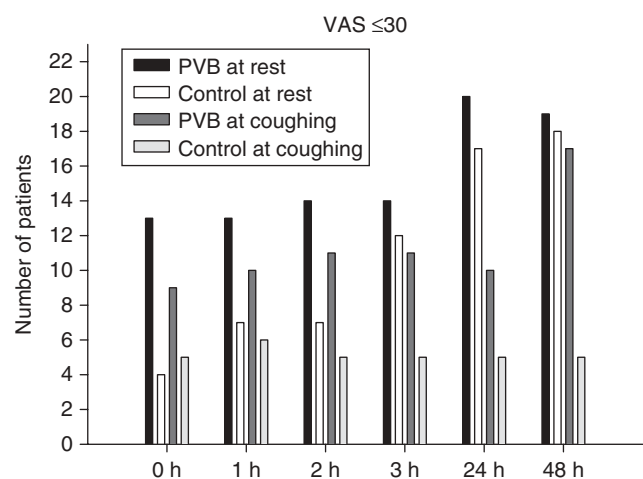
considered for analysis, 20 in the paravertebral group and 20 in the control group.

The characteristics of the patients, duration of surgery and total doses of intraoperative opioids and propofol are shown in Table 1. There was a higher total dose of intraoperative propofol and fentanyl ( $P < 0.05$ ; Mann-Whitney rank sum test) used in the paravertebral group.

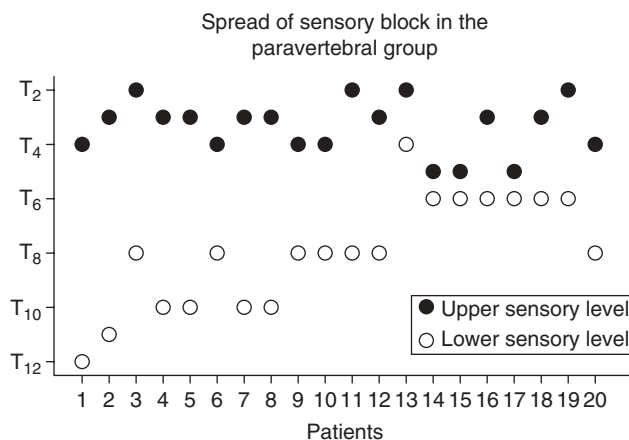
Surgery started 50 min (median) after injection of the local anaesthetic (range 30–90). The types of video-assisted thoracoscopic surgery performed in the two groups are listed in Table 2. There were always three ports used, scattered over two or three intercostal spaces.



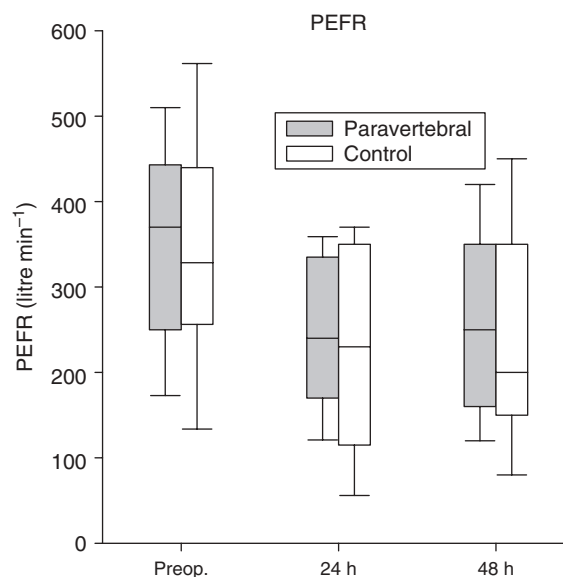
**Fig 2** Course of pain on coughing during 48 h after surgery. The median, interquartile range (box) and the 5th and 95th centiles are shown. The difference between the groups was statistically significant ( $P < 0.05$ ; two-way repeated measures ANOVA on ranks).



**Fig 3** Number of patients with VAS scores  $\leq 30$  mm (i.e. sufficient analgesia) during 48 h after surgery at rest and on coughing.



**Fig 4** The spread of the block is illustrated for each patient with upper and lower levels of sensory block.



**Fig 5** Time course of peak expiratory flow rate (PEFR) preoperatively and after 24 and 48 h after surgery.

The time course of pain scores (VAS) after surgery at rest and at coughing is shown in Figs 1 and 2 respectively. The difference in scores between the two groups at coughing and at rest was statistically significant ( $P < 0.05$ ; two-way repeated measures ANOVA on ranks). During the stay in the postoperative anaesthesia care unit, ketorolac was administered to two and four patients in the paravertebral and control groups respectively. The number of patients with VAS scores  $\leq 30$  is shown in Fig. 3. In Fig. 4 the upper and lower sensory levels of the thoracic dermatomes using cold are shown for each patient.

Half an hour and 3 h after the operation the median (25th–75th percentiles) cumulative morphine consumption, including nurse administered morphine, in the paravertebral group was 7.3 (6.9–8.0) and 21 mg (9.3–28.3) respectively; in the control group it was 6.5 (5.5–8.7) and 20 mg (13–37.3) respectively. The cumulative morphine consumption over

48 h was 69.3 mg (38.8–118.5) in the paravertebral group and 78.1 mg (38.4–93.5) in the control group ( $P = 0.053$ ; two-way repeated measures ANOVA on ranks). One and three patients were treated with ketorolac in the paravertebral group and the control group respectively. No difference was found for patient satisfaction with their pain management.

There was no difference in sedation or the decrease in oxygen saturation after discontinuation of supplementary oxygen (air test) between the groups. Twenty-four and 48 h after surgery the groups did not differ with regard to peak expiratory flow rate (Fig. 5).

The mean length of stay in the postanesthesia care unit was 270 (SD 185) and 279 (192) min for the paravertebral group and the control group respectively (not significant). The median length of stay in hospital after surgery was 4 and 5 days in the paravertebral and the control groups

respectively ( $P=0.53$ ; Mann–Whitney rank sum test). In one patient in the control group a respiratory rate below 8 bpm was documented. The PCA bolus dose was reduced to morphine 1 mg and the respiratory rate normalized. No pulmonary or cardiac complications were observed.

## Discussion

We found that single-shot paravertebral block produced clinically significantly lower pain scores than PCA alone up to 48 h after surgery (Figs 1–3). Our results confirm the findings of previous studies showing that single-injection thoracic paravertebral block reduced the severity of postoperative pain after breast surgery.<sup>19,20</sup>

The main effect of paravertebral block in our study was on VAS scores at rest and on coughing in the first 2 h after the operation. Interestingly, after 24 and 48 h the scores on coughing were still lower in the paravertebral block group. However, at this time a pharmacological effect of bupivacaine cannot be expected. This finding may be explained by a pre-emptive effect of the paravertebral block: reducing the nociceptive input to the central nervous system in the first hour after surgery may have attenuated central sensitization, thereby leading to less postoperative pain.<sup>21</sup>

The factors affecting the spread of bupivacaine in the thoracic paravertebral space have been studied by Cheema and colleagues.<sup>22</sup> They found a mean sensory level of 2.2 segments above and 1.4 segments below the level of injection. In our study, most patients had the upper sensory level two dermatomes above and below the level of injection. This spread is sufficient to block pain sensation after thoracoscopic surgery. Thus, we think that injections in a multilevel fashion would unnecessarily expose patients to additional risks related to punctures.

We found no difference in PEFR between the groups. However, according to Ballantyne and colleagues<sup>23</sup> there is no correlation between surrogate measures of pulmonary function and important outcome measures, such as infection and respiratory failure. Our study was insufficiently powered for us to comment on such outcomes.

There was no difference in cumulative morphine consumption between the groups. This means that single-shot paravertebral block alone may not provide adequate postoperative analgesia and that systemic supplementation may be necessary. In our setting, single-injection thoracic paravertebral block was combined with morphine PCA. However, our results show that in the control group only 20% of the patients had VAS scores  $\leq 30$  mm when coughing after 24 and 48 h; this implies inadequate analgesia.

Thoracic paravertebral block can also be performed using a catheter technique. Canto and colleagues studied continuous bilateral paravertebral block for conventional cardiac surgery.<sup>24</sup> They found low pain scores during the intensive care unit stay, with good haemodynamic stability and a low complication rate. Using a catheter technique would allow

titration of local anaesthetic according to pain scores, which could improve analgesia and reduce the need for systemic analgesia.

We conclude that single-shot paravertebral block is an effective procedure to improve pain treatment after thoracoscopic surgery. The single dose of bupivacaine had a prolonged effect on pain scores on coughing for up to 48 h. Further larger studies are required to evaluate the effect of paravertebral block after thoracoscopic surgery on clinically important outcomes, such as complication rates and the incidence of chronic pain syndrome.

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