Chronic pain in adults after thoracotomy in childhood or youth

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Background. Chronic pain is common after thoracotomy with reported prevalence rates of 20–60%. The pain may be caused by damage to the intercostal nerves during surgery. Some studies have suggested that young age at the time of surgery reduces the risk of developing chronic pain. So far, no studies have examined if children and adolescents develop chronic pain after thoracotomy.

Methods. Eighty-eight patients, mean (SD) age 39.3 (7.7) yr, who underwent thoracotomy between the age of 0 and 25 yr were asked to recall the duration of postoperative pain and—if pain was still present—to describe intensity and character of pain. In addition, all patients underwent quantitative sensory testing.

Results. Fourteen patients (16%) recalled that their postoperative pain had lasted for more than 3 months: one (3.2%) patient in the youngest group (0–6 yr), seven (19.4%) patients in the age group 7–12 yr, and six (28.5%) patients in the age group 13–25 yr (P=0.03). Three out of the 14 patients, who were 11, 11, and 18 yr of age at the time of surgery, still had pain at present. Quantitative sensory testing revealed hypo- and hyperphenomena in most patients, including those with persistent pain. Tactile detection thresholds and pressure detection thresholds were significantly higher on the operated side when compared with the contralateral side (n=88; P<0.001).

Conclusions. The risk of developing chronic pain after thoracotomy seems to be lower if surgery is performed at a young age. Pain after thoracotomy is likely to be of neuropathic origin.

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Chronic pain is a frequent complication after common surgical procedures such as amputation, mastectomy, and inguinal hernia repair.¹ Prevalence rates vary substantially, depending on the type of surgery. For example, between 50% and 85% of amputees experience some degree of stump or phantom pain after limb amputation; after breast surgery up to 30% suffer from chronic pain problems, and after hernia repair persistent pain problems are seen in 12% of patients.² Also, a high proportion of patients are reported to develop long-lasting pain after thoracotomy with prevalence rates varying between 20% and 60%.³–⁶ In some studies, the prevalence is reported to decrease over time;⁷ ⁸ for example, Maguire and colleagues⁸ found that the prevalence of pain after thoracotomy decreased from 57% at 7–12 months to 21% after 6–7 yr.

The causes of chronic pain after surgery are not fully known, but several risk factors have been identified, including female gender, psychological and genetic factors, pre- and postoperative pain, and nerve injury during surgery.¹ In post-thoracotomy pain, it has been suggested that crushing of the intercostal nerves during the surgical procedure plays a role.⁹ ¹⁰ Many patients with post-thoracotomy pain have hyperalgesia and allodynia in the painful area,¹¹ symptoms that are characteristic of neuropathic pain.¹² Another essential element for claiming
neuropathic pain is sensory loss in the painful area corresponding to a relevant nerve. A clear relationship between abnormal sensory findings and pain, however, cannot always be demonstrated, and it has been suggested that factors other than nerve injury contribute to the pain. Previous questionnaire-based studies have reported that a neuropathic component is present in only half of the post-thoracotomy pain patients.

Studies of patients after amputation and inguinal hernia repair have suggested that young age at the time of surgery is associated with a lower risk of developing chronic pain. The mechanisms behind this apparent protection against developing chronic pain in young patients are unknown. Coarctation of the aorta is a malformation that requires surgical intervention during infancy and adolescence. So thoracotomy represents an ideal model to examine whether young age may be protective against the development of chronic pain. To our knowledge, a long-term follow-up examination of these patients with focus on prevalence and in particular the character of their pain has not yet been performed. The aim of this study was two-fold: (i) to determine the frequency of pain and its relationship to sensory function in the painful area and (ii) to determine if age at the time of surgery has any influence on the development of subsequent pain.

Methods

Patients

Patients were recruited from a cohort of patients who participated in another study at the Department of Cardiothoracic and Vascular Surgery, Aarhus University Hospital. In that study, a cardiovascular re-examination was offered to patients who had undergone thoracotomy due to coarctation of the aorta between 1965 and 1985 at Aarhus Kommunehospital, Aarhus, Denmark. Ninety-one consecutive patients who were aged 0–25 yr at the time of thoracotomy received written information about the present study before their visit to Aarhus University Hospital. Patients who wanted to participate (n=88) gave their informed written consent, and assessment of their pain and quantitative sensory testing were performed on the same day as the cardiovascular re-examination. Medical records, if available, were reviewed, to document the type of anaesthesia and postoperative analgesic treatment. The study was performed in accordance with the Helsinki Declaration, and approved by the local ethics committee (2007-0041) and the Danish Data Protection Agency.

Assessment of pain

Patients were asked to fill out a questionnaire about post-thoracotomy pain defined as pain which developed or persisted after surgery and was located to the chest wall on the operated side. Patients were asked to recall the duration of their pain after surgery (<3 months; 3 months–1 yr; 1–3 yr; 3–10 yr; >10 yr; pain still present). If the pain was still present, the patients were asked to rate the average and worst intensity of the pain during the most recent 7 days on a numerical rating scale (NRS, 0–10; 0=no pain; 10=worst possible pain). In addition, they were asked to describe the character of their pain using the following sensory descriptors: burning, painful cold, electric shocks, tingling, pins and needles, numbness, and itching. Patients with persistent pain were also asked about their consumption of analgesic medications and the influence of pain on daily activities.

Effect of age

In order to study the effect of age at the time of surgery on the duration of post-thoracotomy pain, patients were divided into three age groups: 0–6, 7–12, and 13–25 yr. This age division was chosen based on a PubMed MeSH term which defines a child as a person of 12 yr or younger of age. A further subdivision of children (0–12 yr) was based on other studies, which have examined the relationship between age and chronic pain after surgery.

Quantitative sensory testing

All patients underwent quantitative sensory testing, performed by the same investigator (A.D.K.). The patients were examined in a relaxed sitting position and carefully introduced to the different methods used. The length of the surgical scar was measured and the following tests were carried out 3 cm above the scar in the midaxillary line. The ipsilateral and contralateral sides were examined in a randomized order.

Hypo- and hyperaesthesia to touch and prickle were determined by using cotton gauze and a von Frey hair 5.88 (75.86 g), respectively. Both stimuli were started outside the affected area along 7–8 different paths converging towards the centre. Patients were asked to report whether the sensation of touch and prickle either decreased or increased.

Tactile detection thresholds (TDTs) were determined by using von Frey hairs (20 Semmes-Weinstein monofilaments, Stoelting Co., Wood Dale, IL, USA, graded from 0.004 to 446.68 g). The smallest force necessary to bend a von Frey hair, which the patient could just perceive, was defined as the TDT. The up-and-down method was used, and at least three crossings were used to define the threshold.

Pressure pain thresholds (PPTs) to pinch were determined using a hand-held electronic pressure algometer with a 1 cm² probe area and an application rate of 30 kPa s⁻¹ (Algometer®, Somedic Sales, Hörby, Sweden). The pressure algometer consists of a ‘pistol’ handle and a rod with a pressure-sensitive gauge strain at the tip. The pressure was applied by squeezing a skin fold between the tip of the algometer rod and a plastic grip that fits on to
the rod. The patients were instructed to activate a push-button as soon as the pressure sensation became painful and the pressure value was frozen on a digital display. The average of two measurements was calculated as the PPT.

Dynamic mechanical alldynia was evaluated with a foam brush, which was repeatedly applied to the skin.

Cold alldynia was examined with a thermal roll at 20 °C (Somedic AB, Sweden).

Statistics

Patient characteristics are presented as mean (SD). Differences in the recalled duration of post-thoracotomy pain were examined using Fisher’s exact test. Differences between TDTs and PPTs obtained at the operated and the contralateral side were analysed with the Wilcoxon signed-rank test. Statistical analysis was performed using the software package NCSS (Number Cruncher Statistical System, 2004, McGraw-Hill Companies, Kaysville, UT, USA).

Results

Eighty-eight patients participated in the present study, the majority being males (Table 1). Mean (SD) age at the time of thoracotomy was 9.4 (6.0) yr and the mean age at the time of examination was 39.3 (SD 7.7) yr. A review of the available medical records showed that anaesthesia was induced and maintained with halothane, and postoperative pain was managed with systemic opioids, mostly i.m. nicipon.

Forty-four (50%) patients recalled that the postoperative pain resolved within 3 months after surgery. Thirty (34%) patients did not recall the duration of postoperative pain but had no pain at present. Fourteen (16%) patients had experienced pain for more than 3 months and three out of the 14 patients still had pain at present. One (3.2%) patient in the youngest group (0–6 yr), seven (19.4%) patients in the age group 7–12 yr, and six (28.5%) patients in the age group 13–25 yr recalled that post-thoracotomy pain lasted for more than 3 months (P=0.03) (Table 1).

The three patients who still had pain at present rated the mean/average intensity of their pain during the last week to 2, 5, and 6, respectively, and the worst intensity of their pain to 3, 7, and 8, respectively (NRS, 0–10). Characteristics of the patients and their pain are shown in Table 2.

Quantitative sensory testing

The mean (SD) length of the scar was 41.3 (6.2) cm. Forty-eight (54.5%) patients had hypoaesthesia to touch and 59 (67%) had hypoaesthesia to prick. Twenty-three (26.1%) patients had hyperaesthesia to prick. None of the patients had dynamic mechanical allodynia and only one patient without present pain had allodynia to cold. Hypo-, hyperaesthesia, or both were present in all three patients with present pain (Table 2). TDT and PPT were significantly increased on the operated side compared with the contralateral side (Fig. 1).

Table 1 Patient characteristics and recalled duration of post-thoracotomy pain (n=88), presented as mean (SD) or number (%)

<table>
<thead>
<tr>
<th>Age group (yr)</th>
<th>0–6 yr</th>
<th>7–12 yr</th>
<th>13–25 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (M/F)</td>
<td>22/9</td>
<td>23/13</td>
<td>12/9</td>
</tr>
<tr>
<td>Age at the time of thoracotomy (yr)</td>
<td>3.7 (2.0)</td>
<td>9.3 (1.7)</td>
<td>18.0 (4.5)</td>
</tr>
<tr>
<td>Age at the time of examination (yr)</td>
<td>32.3 (4.5)</td>
<td>39.3 (3.4)</td>
<td>49.4 (4.8)</td>
</tr>
<tr>
<td>Time since surgery (yr)</td>
<td>28.5 (4.1)</td>
<td>30.0 (2.9)</td>
<td>31.4 (3.3)</td>
</tr>
<tr>
<td>Recalled duration of post-thoracotomy pain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;3 months</td>
<td>10 (32.3%)</td>
<td>21 (58.2%)</td>
<td>13 (61.9%)</td>
</tr>
<tr>
<td>Pain more than 3 months</td>
<td>1 (3.2%)</td>
<td>7 (19.4%)</td>
<td>6 (28.5%)</td>
</tr>
<tr>
<td>3 months–1 yr</td>
<td>0</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>1–3 yr</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3–10 yr</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>More than 10 yr, but no present pain</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pain is still present</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>No recall of duration, but pain is not present</td>
<td>20 (64.5%)</td>
<td>8 (22.2%)</td>
<td>2 (10.0%)</td>
</tr>
</tbody>
</table>

Table 2 Characteristics of three patients with chronic pain after thoracotomy

<table>
<thead>
<tr>
<th></th>
<th>Patient A</th>
<th>Patient B</th>
<th>Patient C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (M/F)</td>
<td>M</td>
<td>F</td>
<td>M</td>
</tr>
<tr>
<td>Age at the time of surgery (yr)</td>
<td>11</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>Age at the time of examination (yr)</td>
<td>44</td>
<td>37</td>
<td>44</td>
</tr>
<tr>
<td>Time since surgery (yr)</td>
<td>33</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Intensity of pain during the last week (mean/worst, NRS, 0–10)</td>
<td>6/8</td>
<td>2/3</td>
<td>5/7</td>
</tr>
<tr>
<td>Character of pain</td>
<td>Numbness, itching</td>
<td>Painful cold, electrical shocks, numbness</td>
<td>Tingling, pins and needles, numbness</td>
</tr>
<tr>
<td>Impact on daily activities (+/-)</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Consumption of analgesics (+/-)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Length of scar (cm)</td>
<td>50</td>
<td>46</td>
<td>39</td>
</tr>
<tr>
<td>Hypoaesthesia to touch/prick (+/-)</td>
<td>+/-</td>
<td>+/-</td>
<td>+/-</td>
</tr>
<tr>
<td>Hyperaesthesia to touch/prick (+/-)</td>
<td>-/+</td>
<td>-/+</td>
<td>-/+</td>
</tr>
<tr>
<td>Dynamic mechanical alldynia (+/-)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Alldynia to cold (+/-)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TDT (g)</td>
<td>0.69</td>
<td>0.17</td>
<td>28.84</td>
</tr>
<tr>
<td>PPTs (kPa)</td>
<td>145.5</td>
<td>79</td>
<td>50</td>
</tr>
</tbody>
</table>
The main finding of this study is the demonstration of sensory loss and hypersensitivity to mechanical stimulation in the vicinity of the scar in a large proportion of patients who had undergone thoracotomy in childhood or youth. Quantitative sensory testing was performed in all patients. Hyperaesthesia to prick with a von Frey hair was present in 26.1% of all patients, but other hyperphenomena such as dynamic mechanical allodynia and allodynia to cold were only present in one patient. Hypophenomena were very common as reflected by the significantly higher tactile detection and pressure thresholds on the operated side compared with the contralateral side. Thus, many patients without pain present with hyper- and hypophenomena on the operated side and this confirms previous results showing that the relationship between the findings from quantitative sensory testing and the degree of pain is not always clear.\(^{18}\) The findings from only three patients with persistent post-thoracotomy pain are too insufficient to make definite conclusions, but the presence of hypo- and hyperphenomena in all three patients and the use of words like painful cold, electrical shocks, and pins and needles for description of the pain suggest that the pain is of neuropathic origin.

It has been suggested that the incidence of chronic pain after thoracotomy can be reduced through effective regional anaesthesia.\(^6\) The low incidence of chronic pain in the present study cannot be explained by the use of paravertebral or epidural blocks as those techniques were not used at our institution at that time.

All three patients with present pain were older than 6 yr at the time of surgery (11, 11, and 18 yr old, respectively). Also, the recalled duration of post-thoracotomy pain was significantly related to older age at the time of surgery. Thus, our findings suggest that young age at the time of thoracotomy may have a protective effect on the subsequent development of chronic pain.

Before accepting this notion, some limitations of our study have to be addressed.

First of all, it is a retrospective study and therefore susceptible to recall bias. It has been shown that patients with chronic pain are likely to overestimate the intensity of previous pain.\(^{19} \, 20\) For example, McBeth and colleagues\(^{20}\) validated adult patient’s recall of hospitalizations in childhood by checking the medical records and found that the number of hospitalizations was significantly overestimated in patients with chronic pain. The fact that only three patients had chronic post-thoracotomy pain suggests that recall bias probably played no or only a minor role. The follow-up period was very long in this study. A high proportion of patients did not remember the duration of postoperative pain, and this lack of recall was most prominent in patients who were <6 yr of age at the time of operation. It can be argued that the duration of postoperative pain was underestimated, especially in this group. However, several studies have shown that even young children can recall previously experienced pain for months and years.\(^{21}\) Also, prolonged postoperative pain in childhood probably has some impact on daily life\(^{22}\) and is likely to be remembered in adulthood. To our knowledge, no studies have examined children’s long-term (30 yr) recall of pain.

Our findings confirm the results from other studies. Wilkins and colleagues\(^{15}\) studied 60 amputees aged 8–18 yr who were missing a limb either due to a congenital limb deficiency or surgery/trauma. Phantom pain was reported by 3.7% in the congenital group and by 48.5% in the surgical group. In the surgical group, the prevalence of phantom pain was 20.5% among amputees who lost their limb before the age of 6 yr, and 85.7% among amputees who lost their limb after the age of 6 yr. Aasvang and Kehlet\(^{16}\) carried out a questionnaire study in adults who underwent hernia surgery before the age of 5 yr. Only 2% of 651 responders had frequent, moderate, or severe pain in the groin area. The prevalence of chronic pain after adult hernia surgery, on the other hand, is reported to be 12%.\(^2\)

The suggested lower prevalence of chronic pain after surgery in childhood may be related to both physiological

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**Fig 1** TDTs (A) and PPTs (B) were measured on the operated and contralateral side, \(n=88\). Results are shown as box plots with medians represented by horizontal lines with the 75th percentiles at the top and the 25th percentiles at the bottom (10 and 90 percentiles are given as whiskers). \(*P<0.001, \) Wilcoxon signed-rank test.

**Discussion**

The main finding of this study is the demonstration of sensory loss and hypersensitivity to mechanical stimulation in the vicinity of the scar in a large proportion of patients who had undergone thoracotomy in childhood or youth. Quantitative sensory testing was performed in all patients. Hyperaesthesia to prick with a von Frey hair was present in 26.1% of all patients, but other hyperphenomena such as dynamic mechanical allodynia and allodynia to cold were only present in one patient. Hypophenomena were very common as reflected by the significantly higher tactile detection and pressure thresholds on the operated side compared with the contralateral side. Thus, many patients without pain present with hyper- and hypophenomena on the operated side and this confirms previous results showing that the relationship between the findings from quantitative sensory testing and the degree of pain is not always clear.\(^{18}\) The findings from only three patients with persistent post-thoracotomy pain are too insufficient to make definite conclusions, but the presence of hypo- and hyperphenomena in all three patients and the use of words like painful cold, electrical shocks, and pins and needles for description of the pain suggest that the pain is of neuropathic origin.

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The suggested lower prevalence of chronic pain after surgery in childhood may be related to both physiological
and psychological factors. An immature peripheral and central nervous system combined with an enhanced neuronal plastic capacity in the child's brain may contribute to a lower risk of developing chronic pain.23 Bones, tendons, and ligaments are more indulgent and flexible in children, and therefore, thoracotomy, including the use of rib retractors, may be less harmful in children than in adults. Psychological aspects may also play an important role. In adults psychological aspects such as fear of surgery have been found to be associated with more acute pain.24 Children may not worry about the risk of having thoracotomy to the same extent as adults.

In conclusion, this study suggests that the prevalence of chronic pain after thoracotomy is lower if surgery is performed in childhood, and that chronic post-thoracotomy pain is of neuropathic origin. Prospective studies with a long-term follow-up, including quantitative sensory testing, are needed in order to improve our knowledge about the prevalence of chronic pain after surgery in children.

**Funding**

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