The treatment of chronic thoracic segmental pain by radiofrequency percutaneous partial rhizotomy

ROBERT J. STOLKER, M.D., ARNOUD C. M. VERVEST, M.D., AND GERBRAND J. GROEN, M.D., PH.D.

Pain Clinic, University Hospital, and Department of Functional Anatomy, Rudolf Magnus Institute for Neurosciences, Utrecht University, Utrecht, The Netherlands; and Pain Clinic Rodenkirchen, Cologne, Germany

Forty-five patients, 12 men and 33 women with an age range of 17 to 88 years (median 52 years), were selected for a posterior thoracic percutaneous partial rhizotomy (PPR) based on the following criteria. Each patient had at least a 6-month history of irradiating pain that followed the segmental pattern of an intercostal nerve and had not responded to conservative treatment. In addition, no causal treatment was available and there was a temporary positive response to an intercostal blockade with lidocaine.

In the lower thoracic region (T8–12) PPR was performed with the usual dorsolateral technique; in the upper thoracic region a dorsal approach was used by means of a drill hole made with a Kirschner wire in the vertebral arch. The 45 patients underwent 53 thoracic PPR operations. Patients were evaluated 2 months after treatment. Thirty patients (66.7%) were pain-free: in 11 cases (24.4%) more than 50% improvement was achieved, and in four (8.9%) there was no improvement. Side effects consisting of a transient burning pain or a mild transient sensory loss occurred in eight patients (17.7%). After a follow-up period of 13 to 46 months (median 24 months) results were evaluated in 41 patients; five patients had undergone reintervention. Excellent long-term results were achieved in 20 patients (48.8%), good results in 15 (36.6%), and poor results in six (14.6%).

It is concluded, that when conservative treatment fails, thoracic PPR may prove an effective and safe treatment for chronic segmental thoracic pain.

KEY WORDS  thoracic spine  pain  radiofrequency lesion  rhizotomy  operative procedure

There are several causes of segmental thoracic pain: disease and/or lesions of the ribs, disorders of the thoracic spine (for example, fractures, arthritis, metabolic disorders, and tumors), or neuropathies originating from spinal roots, spinal nerves, or intercostal nerves. Some of the pain syndromes are iatrogenic, such as postmastectomy and post-thoracotomy syndromes and pain in the scar tissue after upper abdominal surgery; in some syndromes, such as intercostal neuralgia, the cause is unknown. Extensive examination of patients is obligatory in order to make an accurate diagnosis prior to referral to a pain clinic and to avoid merely symptomatic treatment in patients in whom treatment of the underlying cause is indicated.

When segmental pain becomes chronic and resistant to conservative treatment such as drug therapy, physical therapy, or transcutaneous nerve stimulation, nerve blocks may be used for diagnostic purposes and to achieve pain relief. Since these blockades are of short duration, neurolytic techniques were introduced to obtain control of pain for longer periods of time. Percutaneous neurolytic blockade of the intercostal nerve with alcohol or phenol was popular for a time but had the disadvantage of frequently causing very painful neuritis. Moreover, these blocks may lead to permanent sensory and motor loss and they provide pain relief for only a few months. Furthermore, absolute control over diffusion of the neurolytic fluid cannot be guaranteed. Cryolesions are more controllable but share the other disadvantages of neurolytic fluids.

Surgical rhizotomies have been performed to achieve long-lasting pain relief. Short-term results were very encouraging, but in many studies the high success rate was found to have diminished at long-term follow-up examination, and in several cases sensory deafferentation had appeared. Microsurgical techniques were developed with the intention of avoiding this complication, but surgery is still required and sensory loss cannot be avoided in all cases. Radiofrequency procedures are advocated for their controllability, relative lack of discomfort, and...
Percutaneous rhizotomy in thoracic segmental pain

TABLE 1
Clinical diagnoses and long-term results in 45 patients undergoing percutaneous partial rhizotomy

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Total Cases</th>
<th>Long-Term Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pain-Free</td>
</tr>
<tr>
<td>intercostal neuralgia</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>abdominal wall neuralgia</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>postthoracotomy syndrome</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>intercostobrachial neuralgia</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>postmastectomy syndrome</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>abdominal scar</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>rib tumor</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>pseudarthrosis of a rib</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12h rib syndrome</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>rib resection</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>osteoporosis</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>vertebral metastasis</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>spinal pain</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>traumatic collapsed vertebra</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>total cases</td>
<td>45</td>
<td>20</td>
</tr>
</tbody>
</table>

longer-lasting effects. The technique of percutaneous partial rhizotomy (PPR) was first described by Uematsu, et al. Other authors have performed this procedure in the cervical, thoracic, lumbar, and sacral regions. In this paper the indications and results of thoracic PPR are discussed. In addition, a technique for PPR in the upper thoracic region, using a drill hole made with Kirschner wire, is described.

Clinical Material and Methods

Patient Population

Forty-five patients, 33 women and 12 men whose ages ranged from 17 to 88 years (median 52 years), were selected for this study based on the following criteria: 1) Patients had irradiating pain in the thoracic region that followed a segmental pattern; 2) there was no response to conservative treatment such as drug therapy, physical therapy, and transcutaneous nerve stimulation; 3) duration of symptoms was more than 6 months; 4) no causal therapy was available; and 5) there was a temporary positive response to an intercostal blockade with lidocaine. Patients with loss of sensation in the painful area (such as post-herpetic neuralgia), those with a major psychiatric disorder, and those with compensation liability suits in process were excluded from this study.

The clinical diagnoses are summarized in Table 1. Symptoms were unilateral in all but one patient, and had lasted from 6 months to 51 years (median 3 years). All patients were screened extensively by up to five specialists and were finally referred to the pain clinic by a general practitioner (12 cases) or by specialists (33 cases). Twenty-six of the 45 patients were still using analgesic agents at the time of treatment. X-ray studies showed abnormalities in 18 cases (40.0%): metastasis in the vertebral body in three, traumatic collapse of the vertebral body in one, osteoporosis in three, degenerative changes in the thoracic spine in six, an old rib fracture in two, pseudarthrosis of the rib in one, tumor in a rib in one, and partial resection of the thorax wall in one.

To select patients for this study, 114 intercostal blockade procedures were performed on 94 patients. In the 45 patients selected, the response to 59 intercostal blockades provided an indication for posterior rhizotomy at 53 levels. In the other 49 patients either the response was insufficient to justify a percutaneous rhizotomy (48 patients) or blockade with local anesthetics resulted in prolonged pain relief (one patient).

Intercostal Blockade

Intercostal blockade was performed by the classic method: a 100-mm No. 22 needle was advanced under fluoroscopy to the caudal margin of the rib and slipped under the rib. Contrast medium (iohexol) was injected to visualize the nerve (Fig. 1). Of course, at the T-12 level, the subcostal nerve is the target of the blockade. Patients with a positive response (> 50% pain relief) to the prognostic blockade were selected to undergo the PPR procedure.

Percutaneous Partial Rhizotomy

In the lower thoracic region (T8–12) PPR is performed with a 100.5-mm No. 22 cannula with a 5-mm active tip. Under fluoroscopy with a 15° oblique view, the electrode is positioned just caudal to the pedicle with the tip, seen from an anteroposterior (AP) view, exactly in the middle of the pedicle. The depth of the electrode is frequently checked from a lateral view. The tip of the electrode must be placed in the craniodorsal part of the foramen, which is the anticipated position of the dorsal ganglion. The stylet is removed and a 10-cm thermocouple electrode is inserted. A stimulation current with a frequency of 50 Hz and a range of 0.4 to 0.8 V should elicit a tingling sensation in the corresponding dermatome. A stimulation current with

* Sujit-Mehta 10-cm thermocouple electrode obtained from Radionics, Inc., Burlington, Massachusetts.
a frequency of 2 Hz should not elicit intercostal muscle contractions below a threshold that is twice as high as the sensory threshold. Contrast medium (iohexol) is injected to visualize the nerve and avoid intravascular positioning of the electrode (Fig. 2). The nerve is then blocked with 2% lidocaine and a thermolesion is made at a temperature of 67°C and a duration of 90 seconds.

In the upper thoracic region (T1–7) this technique is usually not possible, since the configuration of the laminae prevents easy passage of the electrode, and a more lateral approach is unsafe because of the proximity of the pleura. Hence, from an AP view at a point that is projected as just caudal to the pedicle and equidistant from the medial and lateral borders of the interpedicular space, skin and subcutaneous tissues are anesthetized with 2% lidocaine. A small skin incision is made with a scalpel, and a No. 14 guidewire with a stylet in place is introduced under continuous AP and lateral fluoroscopic control and advanced until there is contact with bone. The stylet is then removed and a Kirschner wire is used to make a drill hole using a small pneumatic drill, still under AP and lateral visualization with the fluoroscopic image intensifier. If access to the foramen has been obtained, the Kirschner wire is withdrawn and a No. 16 rhizotomy electrode† with a 4-mm bare tip is inserted (Fig. 3). The further procedure described above is then followed.

**Results**

The 45 patients in this study underwent 53 PPR procedures. Thirty-seven patients received a single rhizotomy, one patient was treated bilaterally, and seven patients were treated at two levels. The results were evaluated using a five-grade oral analog scale. At the first evaluation, 2 months after treatment, 30 patients (66.7%) were pain-free, 11 patients (24.4%) obtained more than 50% pain relief, and four (8.9%) obtained no pain relief.

Six patients (13.3%) suffered a transient burning pain in the corresponding dermatome that subsided within 3 weeks; only one required treatment with naproxen. In two patients (4.4%) a slight sensory loss in the corresponding dermatome was detected, resolving within 3 months in both cases. No motor loss and no pneumothorax occurred.

Five patients underwent reoperation (Table 2). One patient (Case 1) was not satisfied with her result of more than 50% pain relief and underwent the PPR procedure for a second time. She obtained further but still incomplete pain relief. In two patients (Cases 2 and 3) with initial complete relief, symptoms recurred after 6 and 9 months, respectively. The procedure was repeated and resulted in no relief in Case 2 and more than 50% pain relief in Case 3. After 13 months two other patients (Cases 4 and 5) had recurrent complaints leading to a repeat PPR, with complete relief in Case 4 and more than 50% pain relief in Case 5.

Four patients died from their malignant disease 3, 4, 6, and 18 months after treatment; complete pain relief continued in all four patients until the time of death. Long-term results were obtained in the remaining 41 patients. In three patients with initial complete relief the symptoms recurred, but with less than 50% of the original intensity. In a fourth patient who initially had more than 50% pain relief, the pain recurred in full after 13 months. After a follow-up period of 13 to 46 months (median 24 months), 20 patients (48.8%) were pain-free, 15 (36.6%) obtained more than 50% pain relief, and six patients (14.6%) obtained no relief (Table 1). The results are summarized in Table 3 and are correlated with the level of disease in Fig. 4.

At the time of initial treatment, 26 patients were mainly using analgesic drugs. After treatment 10 patients continued drug therapy: one patient who had no pain relief, one after a complete recurrence of pain, two after partial recurrence, one with more than 50% long-term pain relief because of residual complaints, and four with complete and one with more than 50% pain relief.

---

† Sluijter rhizotomy electrode obtained from Radionics, Inc., Burlington, Massachusetts.
Percutaneous rhizotomy in thoracic segmental pain

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Initial Level of Relief</th>
<th>Timing of Reop (mos postop)</th>
<th>Level of Relief</th>
<th>Duration of Follow-Up (mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&gt; 50%</td>
<td>&gt; initial but</td>
<td>&gt; 50%</td>
<td>41</td>
</tr>
<tr>
<td>2</td>
<td>pain-free</td>
<td>none</td>
<td>&gt; 50%</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>pain-free</td>
<td>&gt; 50%</td>
<td>&gt; 50%</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>pain-free</td>
<td>pain-free</td>
<td>&gt; 50%</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>pain-free</td>
<td>pain-free</td>
<td>&gt; 50%</td>
<td>10</td>
</tr>
</tbody>
</table>

* Reoperation was performed in Case 1 because the patient was dissatisfied with the initial results and in Cases 2 to 5 for recurrent symptoms.

Relief because of other sources of pain. Only two of 11 patients continued opioid intake.

Statistical Analysis

Power calculation of the results, even assuming a placebo effect of 50% and using an unreliability factor (α) of 0.01 (instead of the usual 0.05), shows that the chance of these results being placebo-produced is less than 0.01 (power (1-β) > 0.99).

Discussion

Patient Selection

Segmental pain occurs less commonly in the thoracic region than in other parts of the spine, but the incidence is still considerable.\(^\text{46}\) Cervical pain is about three times more frequent and lumbar pain seven to 10 times more frequent.\(^\text{46}\) Symptomatic pain treatment is indicated only when patients are screened extensively and causal therapy is not available. Our 45 patients were screened by specialists from 16 different disciplines, for a total of 136 examinations. If conservative measures fail, invasive treatment may be of benefit. All patients in this study shared a long history of multiple failed therapeutic attempts; all had used analgesic drugs before our intervention and 26 still used these agents at the time of treatment. These features suggest that the pain was resistant to treatment and that spontaneous recovery in these "therapeutic outcasts" was unlikely to occur, as had been demonstrated in a comparable group of patients.\(^\text{32}\) No tendency toward spontaneous recovery could be observed in this study; patients with poor results remain unimproved.

We emphasize that prognostic blockade is imperative in the selection procedure, for three reasons: 1) to confirm the clinical diagnosis of segmental pain; 2) to determine the appropriate level of treatment; and 3) to assess the potential benefit of PPR. However, as stated by other authors, treatment failure after a positive prognostic block is still possible.\(^\text{20,26,36,45}\) Such treatment failure may be due to the more localized action of a radiofrequency lesion compared to local anesthetics,\(^\text{2,3,22}\) technical failures from heat loss via nearby blood vessels,\(^\text{5}\) afferent fibers in the ventral root,\(^\text{4}\) ectopic ganglion cells,\(^\text{12}\) intersegmental nervous connections,\(^\text{51}\) sympathetic maintenance of pain,\(^\text{48}\) or a placebo effect of the prognostic block.\(^\text{57}\)

Our short-term results indicate that in most cases the selection procedure, including the prognostic block, has been adequate. This is in keeping with reports by others.\(^\text{25,26,45}\) However, some authors state that results of prognostic blockade do not adequately predict the result of the final procedure.\(^\text{20,26}\) The reliability of prognostic blockade in our study, confirmed by the success rate, may be explained by 1) the use of an image intensifier to verify the level and the arrival of local anesthetics at the nerve and 2) the ability to block the nerve at a peripheral site in the thoracic region (that is, the intercostal nerve), thus avoiding overflow into the epidural space and the sympathetic system.\(^\text{34}\) Nevertheless, a PPR is never indicated in patients who have a negative prognostic block.\(^\text{5}\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Total Cases</th>
<th>Pain-Free</th>
<th>&gt; 50% Relief</th>
<th>&lt; 50% Relief</th>
</tr>
</thead>
<tbody>
<tr>
<td>short-term results (2 mos post-PPR)</td>
<td>45</td>
<td>30</td>
<td>66.7</td>
<td>11</td>
</tr>
<tr>
<td>long-term results (mean follow-up period 24 mos)*</td>
<td>41</td>
<td>20</td>
<td>48.8</td>
<td>15</td>
</tr>
<tr>
<td>reinsertion not considered</td>
<td>19</td>
<td>13</td>
<td>46.3</td>
<td>31.7</td>
</tr>
</tbody>
</table>

* Four patients died within 18 months post-PPR due to malignant disease; all were pain-free until the time of death.

J. Neurosurg. / Volume 80 / June, 1994
Radiofrequency

Surgical Rhizotomy vs. Radiofrequency PPR

The success rate of surgical rhizotomy varies from 15% to 100%,19,20,25-27,35-37,49-51 with a follow-up period of up to 20 years. In some studies the success rate diminishes dramatically between 15% and 28%, after periods ranging from months to years.20,26 Loeser26 and White and Kjellberg26 stated that if successful results last more than 6 to 24 months they will usually be permanent.

In series of patients treated with radiofrequency PPR, success rates vary from 50% to 85% and temporary relief has been observed in a smaller percentage of patients; side effects are less frequent and/or less serious.17,23,24,30,36,42-45 Follow-up data have been reported for up to 6 years. Long-lasting benefits of radiofrequency lesions were also found after PPR in the treatment of a hyperreflexic bladder21 and spastic cerebral palsy.27

In our review of the literature we were surprised to find that the results of surgical rhizotomy in the thoracic region were better than results in other regions.1,9,37,5 Our outcome in the thoracic region is comparable to data from other studies of radiofrequency PPR. In some of these studies a substantial part of the patient population was treated at more than one level, whereas in our study 37 patients (82%) were treated at one level only. The relatively simple segmental pain patterns related to the organization of the nervous system in the thoracic region might be a reason for these improved results.51

Radiofrequency Lesions in PPR

There is some controversy about the character of radiofrequency lesions. Letcher and Goldring18 stated that small fibers are more susceptible to heat, while others could not demonstrate this specificity.22,38 (It should be emphasized that most studies are in vitro investigations). We agree with Bogduk, et al.,2 that correct positioning of the electrode seems to be the crucial technical factor required for a successful outcome. Also, use of a lower temperature may diminish the risk of denervation. In our experience the combination of a sensory stimulation threshold within the range of 0.4 to 0.8 V and a temperature of 67°C for 90 seconds provided the best results.45 A lower stimulation threshold could lead to complete destruction of the ganglion comparable to the objective sensory loss caused by some surgical procedures.38 Clinically, this sensory loss may be difficult or impossible to detect because of overlap of dermatomes.10 A recent study showed no alterations in sensory evoked potentials and electromyography studies before and after cervical PPR.43 This seems to support our opinion that this procedure is a partial, rather than a complete, rhizotomy. However, in two patients in our study, a slight hypalgesia in a part of the corresponding dermatome was detected, subsiding in a few weeks. This may mean that radiofrequency PPR, if performed at too high a temperature, could lead to severe sensory loss. However, analogous to trigeminal nerve rhizotomy (the procedure, not the presenting illness, is comparable), in which (slight) postoperative hypalgesia is common, this sensory loss is expected to be transient and not cause deafferentation, provided that the damage is not too extensive.14,38 In PPR, detectable sensory loss in the dermatome is never a goal and is seldom observed. Despite earlier opinions this partial characteristic of the lesion might explain the less marked shift of long-term results (from excellent to good and good to poor pain relief) compared with the outcome of neurolytic lesions, cryolesions, and surgical rhizotomies.20,25,26,80

In accordance with the concept that total interruption of sensory pathways is necessary to obtain pain control, surgical rhizotomies have often been performed at multiple levels. However, the long-term results were disappointing. This may be due to sensory loss followed by alterations in the plasticity of the dorsal horn, leading to deafferentation pain.10,20,29,39 Contrary to the general practice in surgical rhizotomy and lumbar and cervical radiofrequency PPR, most of our patients were treated at one level only. The phenomenon of expanding receptive fields after complete rhizotomy, as described by Ovelmen-Levitt, et al.,29 was not observed in our patient group. These observations all suggest a partial lesion of the ganglion, but the anatomical substrate of the radiofrequency lesion has remained unclear up to now.9 This is the subject of one of our recent studies.13

Technique and Complications of PPR

We stress that radiofrequency procedures must never be performed without fluoroscopic control. Fluoroscopy facilitates not only adequate positioning, but also objective (for example, medicolegal) verification of the position of the needle tip. Although computerized tomography (CT)-aided positioning has been advocated,41 the use of a fluoroscopic image intensifier has proved to be as reliable as CT in determining the needle position, as was confirmed in anatomical specimens.18

A PPR is difficult to perform in the upper thoracic region for anatomical reasons: the shape of the lamina and the intervertebral foramen induce a more lateral approach which is, however, contraindicated by the proximity of the pleura.1,30,44 Therefore, in this region a dorsal approach has been used via a drill hole created by Kirschner wire as described in the sacral PPR procedure.38 Another reason for avoiding a dorsolateral approach is that it may cause serious complications.16 Although Koning, et al.,16 stated that the best explanation of the observed incomplete Brown-Séquard syndrome would be a vascular steal phenomenon caused by vasodilatation from local heating by the radiofrequency electrode, in our opinion this is erroneous. A unilateral direct lesion in the spinal cord is more probable, since the lesions were found at those spinal cord segments that lie exactly at the level of the rhizotomies performed and at a location that is a precise extension of the track of the electrode. Furthermore, a steal phenomenon is unlikely because of the size of the radicular arteries,33 and in addition would lead to bilateral neurological deficits at the level of the rhizotomy rather than a unilateral syndrome one level below.
Percutaneous rhizotomy in thoracic segmental pain

Serious complications were not encountered in our series. We feel that this dorsal approach is safe. The only side effects were loss of sensation and some post-operative pain, both of which were transient. As this neuritis-like pain has been reported in almost all radiofrequency studies,7,23,34,36,45 it seems to be related to the technique itself. It has been claimed that the use of thin No. 22 electrodes should minimize this problem.36

Conclusions

Thoracic PPR at one or two levels may provide adequate pain relief if other symptomatic pain treatments have failed. Long-term results before now have shown only a slight worsening of symptoms and no evidence of deafferentation pain. Complications of this procedure appear to be minor if performed by experienced hands. Proper patient selection and the use of prognostic selective intercostal blockade make it possible to achieve good results. Compared to surgical rhizotomy the procedure is easier, success rates are higher, side effects are less serious and/or less frequent, and the likelihood of deafferentation is smaller. Power analysis of the results shows that the chance of our results being due to a placebo effect is less than 1%. Continued investigations of the anatomical aspects, elucidation of the physiological mechanisms, longer follow-up monitoring of this patient group, and a controlled clinical trial will be necessary before the value of this therapy can be assessed further.

Acknowledgments

The authors thank Dr. A. B. Vaughan for her help in preparing the manuscript. Prof. C. A. F. Tulleken, Prof. J. T. A. Knape, and Dr. N. Lamboom for their critical review; Mrs. I. van der Tweel for statistical assistance; and C. Timmers for the photographs.

References


R. J. Stolker, A. C. M. Vervest, and G. J. Groen

Manuscript received March 2, 1993.
Accepted in final form September 24, 1993.
Address reprint requests to: Robert J. Stolker, M.D., Department of Functional Anatomy, Utrecht University, Stratenum Building, P.O. Box 80039, 3508 TA Utrecht, The Netherlands.