Interdisciplinary Neurosurgery: Advanced Techniques and Case Management 6 (2016) 80–83

Contents lists available at ScienceDirect

Interdisciplinary Neurosurgery: Advanced Techniques and Case Management

journal homepage: www.inat-journal.com

Technical Note & Surgical Technique

Anterior cingulotomy for intractable pain

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ARTICLE INFO

Article history:
Received 25 September 2016
Accepted 1 October 2016

Keywords:
Anterior cingulotomy
Intractable pain
Stereotactic

ABSTRACT

Conservative therapy is often the first-line treatment for many symptoms of various disease processes, including pain. Nevertheless, if pharmacological or medical management fails for those patients with severe and chronic pain, a surgical strategy may be a reasonable option. First performed for psychiatric disorders, cingulotomy now has been recognized as a viable option for the management of pain. The authors review the literature on anterior cingulotomy for intractable pain to provide guidelines for management and expected outcomes.

1. Introduction

Conservative therapy is often the first-line treatment for many symptoms of various disease processes, including pain. Nevertheless, if pharmacological or medical management fails for those patients with severe and chronic pain, a surgical strategy may be a reasonable option. Amongst the surgical options there are neuromodulation or neuroablative procedures, including cingulotomy [1]. First performed for psychiatric disorders, cingulotomy now has been recognized as a viable option for the management of pain. Bilateral cingulotomy targets the anterior cingulate cortex, a part of the limbic system controlling integration of feelings and emotion [2]. As with other ablative procedures, concern exists regarding the destructive nature of the procedure and uncertainty regarding its mechanism of action. As such, the authors review the literature since the 1990s on anterior cingulotomy for intractable pain to provide guidelines for management and expected outcomes.

1.1. Historical perspectives

Following the introduction of frontal lobotomy by Egas Moniz in the mid-1930s, interest in decreasing the associated morbidity and mortality of the psychiatric surgery led physicians to search for alternative approaches that would still realize the desired psychiatric changes [3]. The concept of a cingulotomy was introduced by American physiologist John Fulton at a meeting of the Society of British Neurosurgeon in 1947. As Fulton stated, "were it feasible, cingulectomy in man would seem an appropriate place for limited leucotomy" [4]. In 1948, Cairns performed the first anterior cingulectomy [5]. The results of 15 of these operations for a variety of psychiatric illnesses by Cairns and his colleagues were reviewed by Lewin in 1961 [6]. In 1962, Foltz and White reported a case series of patients who underwent stereotactic cingulotomy for intractable pain [4]. Later, Ballantine et al. reported complications in a series of 12 patients with intractable pain; however, no deaths were attributable to their technique [4]. Finally, in 1968, Foltz and White utilized anterior bilateral stereotactic cingulotomy extensively in their report on patients in whom "incapacitating pain seemed to be significantly augmented by emotion factors." [7].

1.2. Surgical procedure

Originally performed using ventriculography, cingulotomy is now conducted using magnetic resonance image (MRI) guided stereotactic technique. Direct visualization of targeted tissue clearly favors MRI guided stereotactic techniques. Preoperative preparation includes mapping out the cingulate cortex. Under intravenous sedation with local anesthesia at pin insertion sites, a stereotactic MR-compatible frame is fixed to the patient's skull. Utilizing oblique coronal MR images, tissue of the anterior cingulate gyrus is targeted approximately 2 to 2.5 cm posterior to the tip of the frontal horn, 7 mm from the midline and 2 to 3 mm above the corpus callosum bilaterally [8].

The patient is then placed on the operating table in a supine or semi-reclining position and the stereotactic frame is secured into position. Following skin incision, burr holes are drilled 15 to 25 mm from the midline. The dura is opened with caution to avoid cortical vessels. The thermocoagulation electrodes are inserted under stereotactic guidance (Fig. 1). The target tissue is heated to 85 degrees Celsius for 90 s utilizing a standard thermocoagulation electrode (Radionics, Inc., Burlington,

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http://dx.doi.org/10.1016/j.inat.2016.10.005

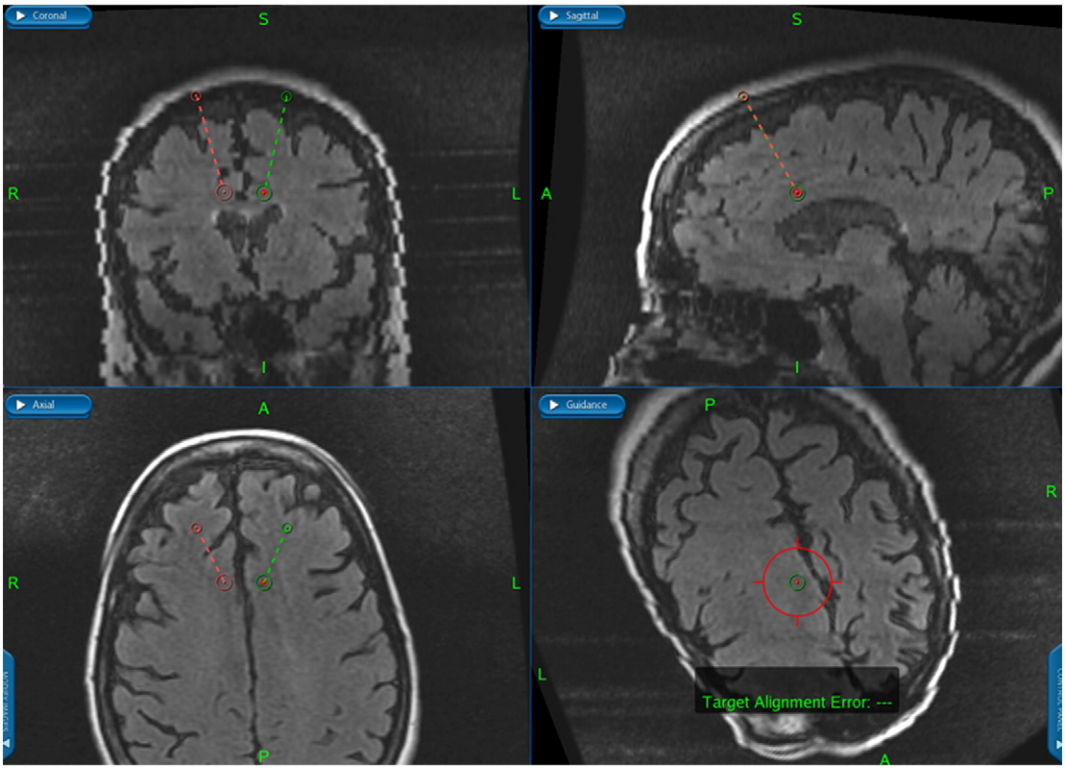

Fig. 1. Target localization utilizing Medtronic Stealth navigation (Medtronic Inc., Minneapolis, MN).

MA) with a 10 mm uninsulated tip. After cooling, the electrode is withdrawn approximately 5 to 10 mm whereby a second lesion is made in accordance with the parameters for the initial lesion. The aforementioned procedure is then completed in an identical manner for the contralateral side (Fig. 2a and b). Of note, in recent years, three lesions are placed to ensure complete ablation and reduce the need for subsequent lesioning procedures [8].

2. Methods

We searched the following electronic databases: PubMed, CENTRAL (The Cochrane Library), MEDLINE, and EMBASE. Our search terms were "anterior cingulotomy" and "cingulotomy pain." No language restriction was implemented. Patients must have pain refractory to pharmacological or medical management. Outcome was alleviation of symptoms per the patients.

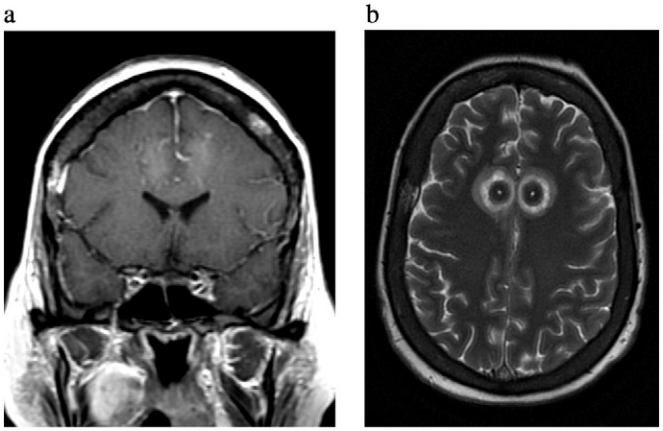

Fig. 2. Post-ablation a) coronal and b) axial MRIs depicting bilateral anterior cingulotomy.

3. Results

3.1. Literature search

The combined search strategy identified 365 records (Fig. 3). After review, 9 articles investigating change in severity of intractable pain following anterior cingulotomy were identified (Table 1).

3.2. Patient outcomes

Half of the patients in the studies reviewed received bilateral anterior cingulotomy for non-cancer pain (41 patients) versus cancer pain (41 patients). A wide variety of non-cancer indications for cingulotomy were reported and included post-traumatic neuropathic pain, atypical facial pain, diabetic neuropathy, and phantom pain. The majority of studies we reviewed used MRI for localization, although two reported use of computed tomography (CT). Quantification of pain improvement was uneven between studies – two studies used the Visual Analog Scale (VAS), one used a 10 point Likert scale, and one used the McGill pain scale. Improvement in pain following cingulotomy was reported to range from 50 to 100% overall with similar results between cancer pain and non-cancer patients [1,9–16].

4. Discussion

Postoperative pain relief following anterior cingulotomy has been cited as temporally bimodal. Following their procedure, patients may be confused and ignore their pain. However, as the confusion clears the pain may return. Ultimately, patients may become habituated towards their pain [2]. Patients must be carefully followed with serial neurological examinations for early detection of any complications. An immediate, postoperative MRI scan is recommended to document the lesion site, lesion volume, and detect any complications. Patients recover well enough for discharge from the procedure after approximately 4 days, but some report recovery in as little as 48 h postoperatively.

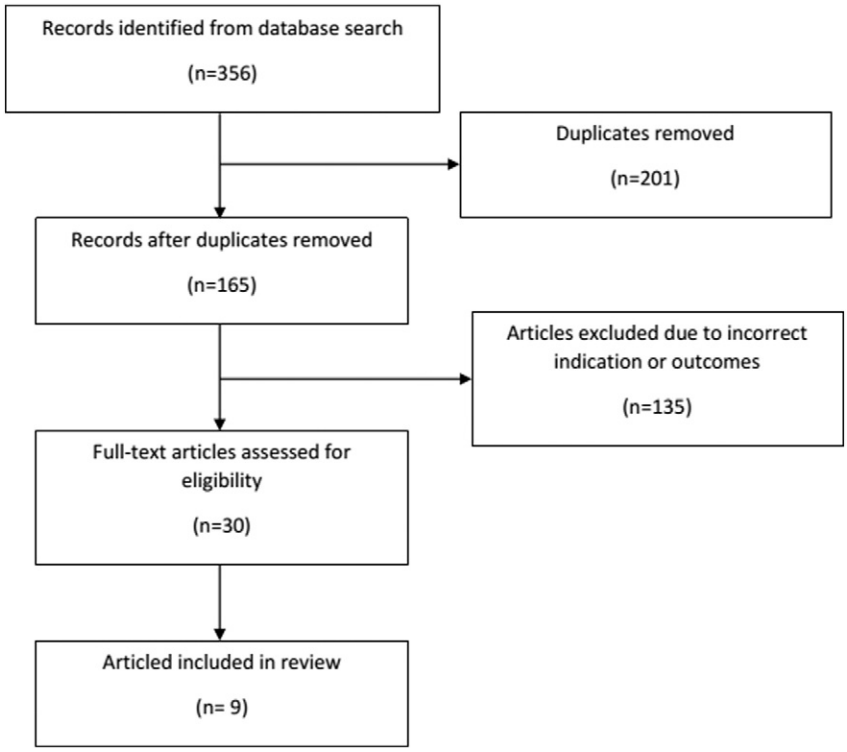

Fig. 3. Anterior cingulotomy search strategy.

Although anterior cingulotomy demonstrates effectiveness in pain control, surveillance for adverse effects is important. Observed side effects include headaches, nausea, vomiting, and seizures [17]. While a spectrum of cognitive side effects have been reported following cingulotomy, cases with no adverse effects have been documented [18]. In a controlled trial on patients treated with cingulotomy for intractable pain, Cohen et al. reported postoperative executive and attention impairments. On one-year follow-up, the aforementioned deficits mostly resolved, with residual impairments of intention, attention, and spontaneous response production [12]. Additional reports have cited cognitive side effects with defects in visual-spatial processing and simple motor skills [19,20].

5. Conclusion

Bilateral anterior cingulotomy is generally used when more conservative medical, surgical, and pharmacological methods have not succeeded. First utilized for patients with psychiatric problems such as anxiety, obsessive-compulsive disorders, and depression, anterior cingulotomy has for several decades been a treatment option for chronic pain. Given its ability to provide relief to any body region, anterior cingulotomy proves to be a versatile therapeutic strategy. Patients often recover relatively quickly with self-limited complications. Overall, stereotactic bilateral anterior cingulotomy has been demonstrated to be efficacious for the treatment of refractory and intractable pain.

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, material, or devices described in this article.

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Table 1
Results of literature review for anterior cingulotomy.

Authors & year	Study design	Number of patients	Type(s) of pain	Mean age at surgery	Localization	Laterality of cingulotomy	Follow up	Outcome
Hassenbusch et al., 1990	Case series	4	Cancer	56.3 years	MRI	Bilateral	2, 4, and 6 weeks for 3 of 4 patients. 4 months for 1 patient	4 of 4 (100%) reported significant pain relief at all time points
Pillay et al., 1992	Case series	10	Cancer (8) Noncancer - neurofibromatosis and thalamic stroke (2)	51.9	MRI	Bilateral	6 month for cancer patients 1 year for noncancer patients	5 of 8 (62.5% of cancer patients reported good to excellent pain relief 1 of 2 (50%) of noncancer patients reported good pain relief
Wong et al., 1997	Case report	3	Cancer	46.0 years	MRI	Bilateral	Unclear	3 of 3 (100%) of patients reported significant pain relief immediately following their procedure and were discharged on significantly lighter pain medication regimens.
Cohen et al., 1999	Controlled trial	12	Noncancer - noncerebral traumatic injury	Range: 40–58 years	CT	Bilateral	1 year	8 of 12 (66%) experienced improvement on a 10 point Likert scale
Wilkinson et al., 1999	Case series	18	Wide variety of noncancer pain including lumbar or sciatic pain, phantom pain, and atypical facial pain	Range: 32 to 77 years	A few early cases used air ventriculography and the remainder used CT	Bilateral	Mean follow up of 7.7 years	13 of 18 (72%) reported sustained improvement at via a VAS questionnaire.
Yen et al., 2005	Case series	22	Cancer (15) Noncancer including diabetic neuropathy, post-spinal cord injury pain, and trigeminal neuralgia (7)	58.3 years	MRI	Bilateral	1 week and 6 months for all patients	50–80% of cancer patients reported relief at some time point and 71–100% of patients with other causes of pain reported relief per the VAS.
Yen et al., 2009	Case series	10	Cancer	64.4 years	MRI	Bilateral	1 week and 3 months	6 of 10 (60%) of patients had fair to good pain relief at both time points per the McGill pain questionnaire.
Tsai et al., 2013	Case report	2	Neuropathic pain secondary to cervical and thoracic spine trauma	Not reported	MRI	Bilateral	Unclear	2 of 2 (100%) reported pain relief - one patient experienced transient exacerbation of pain before gradual improvement
Pereira et al., 2014	Case report	1	Cancer	67 yo	MRI	Bilateral	5 months	1 of 1 reported pain relief