We obtained samples of spinal accessory nerve from patients undergoing radical surgery for tumours or nerve grafting in the neck. These were analysed by light and electron microscopy for the type of fibre. All contained fibres consistent with non-proprioceptive sensory function including pain.

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The spinal accessory nerve is regarded as being purely motor in function. This is the description given in standard anatomical and surgical texts. It is said not to contain nociceptive fibres. Our aim was to confirm or refute this statement and to investigate the type of fibre within the nerve.

Pain is associated with iatrogenic injury to the nerve. It is thought to be due to mechanical drooping of the shoulder and a traction neuritis of parts of the brachial plexus. We suspected that the pain might originate from the cut nerve itself.

Patients and Methods

We used four samples of the spinal accessory nerve. Three were obtained from patients undergoing radical surgery for carcinoma in the neck and one from a patient having a nerve graft after injury to the brachial plexus. Three patients were adult men aged 53, 58 and 28 years. The fourth was a woman aged 56 years. Three samples were taken from the left side of the neck and one from the right at three different points along the course of the nerve. An upper section was taken at the exit from the jugular foramen, two middle sections from adjacent to the sternocleidomastoid and a lower section from the distal region of the posterior triangle of the neck just before the nerve entered the trapezius.

On removal, the nerve biopsies were immediately immersed in a cold fixative of 2% paraformaldehyde and 2.5% glutaraldehyde in 0.1M sodium cacodylate buffer (pH 7.4) and were left overnight at 4°C. The tissue was trimmed and postfixed in 1% osmium tetroxide in 0.1M sodium cacodylate buffer (pH 7.4) for one hour at 4°C. It was then dehydrated with absolute alcohol, cleared in propylene oxide and embedded in TAAB epoxy resin.

Semi-thin sections (1 to 2 µm) were cut on a microtome with a glass knife and stained with Toluidine Blue in borax for light-microscopic examination. Ultrathin sections (80 nm) were prepared with an ultramicrotome and mounted on 200 mesh copper grids. The sections were contrasted with 1% aqueous uranyl acetate and lead citrate and examined with a Philips CM10 transmission electron microscope. On-line measurements were determined using a closed-circuit television system linked to the electron microscope. The package included software which allowed the morphometry of live images after suitable calibration.

Each nerve sample was analysed for the size and number of nerve fibres and the presence or absence of myelin. Three small squares on the calibration grid of the electron microscope were randomly selected and analysed in this way for each sample.

The histological findings were compared with the standard classification of peripheral nerve fibres. Classification into A, B or C fibres is, essentially, in terms of size of the fibre. A standard physiological text classifies the nerve fibres as shown in Table I. From this Table it can be seen that there is some overlap in the size of the fibre between preganglionic autonomic myelinated nerve fibres and Aδ fibres. Similarly, there is an overlap between postganglionic sympathetic fibres and dorsal-root C fibres. There should not, however, be significant amounts of autonomic nerve fibres within the accessory nerve. The cranial preganglionic parasympathetic outflow is through the oculomotor, facial, glossopharyngeal and vagus nerves to appropriate ganglia in the head and thorax. The postganglionic sympathetic fibres reach their destinations through blood vessels after
Unmyelinated fibres in all the samples. These represent A\* responses. Temperature and some mechanoreceptive and reflex responses. The dorsal-root C fibres are known to transmit pain, temperature and some mechanoreceptive, reflex responses. These sympathetic fibres within the spinal accessory nerve. These sympathetic autonomic fibres are of similar dimensions but are not found within the spinal accessory nerve. They are compatible with dorsal-root C fibres contained a high proportion of small (< 2 µm) unmyelinated fibres. These are compatible with dorsal-root C fibres contained a high proportion of small (< 2 µm) unmyelinated fibres. These fibres are inherent to the spinal accessory nerve. Our findings may help to explain the pathology of the spinal accessory nerve and the muscles which it innervates.

Results

The main findings are summarised in Table II. All samples contained a high proportion of small (< 2 µm) unmyelinated fibres. These are compatible with dorsal-root C fibres since there should not be large numbers of postganglionic sympathetic fibres within the spinal accessory nerve. These dorsal-root C fibres are known to transmit pain, temperature and some mechanoreceptive and reflex responses.

There was also a percentage of small (2 to 3 µm) myelinated fibres in all the samples. These represent A\(\delta\) fibres which are known to transmit pain, cold and touch. Preganglionic autonomic fibres are of similar dimensions but are not found within the spinal accessory nerve.

The sample obtained from the jugular foramen contained the same proportions of different-sized nerve fibres as the lower samples which supports the idea that dorsal-root C and A\(\delta\) fibres are inherent to the spinal accessory nerve and do not derive from communications with the cervical plexus.

Discussion

Standard anatomical and surgical texts describe the spinal accessory nerve as a purely motor nerve which supplies motor fibres to the sternocleidomastoid and trapezius muscles. The upper cervical nerves are thought to provide some motor fibres and all the primary afferents to these muscles. These afferent fibres have previously been thought to be merely proprioceptive in function.

We have shown that the spinal accessory nerve in man is not a purely motor nerve. It appears to have within it non-proprioceptive sensory and nociceptive fibres. Our study suggests that these fibres are inherent to the nerve. Communications between the accessory nerve and cervical plexus have been demonstrated by Caliot et al. It is possible that some transfer of nerve fibres occurs between these sources.

Our findings may help to explain the pathology of the spinal accessory nerve and the muscles which it innervates.

Muscles supplied by the spinal accessory nerve are known to be particularly prone to the development of trigger points characteristic of myofascial pain. The transduction mechanisms for the deep pain produced by these muscles have not been established, but nociceptive fibres within the spinal accessory nerve would provide a suitable route.

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**Table I.** Nerve fibre types in mammalian nerve

<table>
<thead>
<tr>
<th>Fibre type</th>
<th>Function</th>
<th>Fibre diameter (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A(\alpha)</td>
<td>Somatic motor, proprioception</td>
<td>12 to 20</td>
</tr>
<tr>
<td>A(\beta)</td>
<td>Touch, pressure</td>
<td>6 to 12</td>
</tr>
<tr>
<td>A(\gamma)</td>
<td>Motor to muscle spindles</td>
<td>3 to 6</td>
</tr>
<tr>
<td>A(\delta)</td>
<td>Pain, cold, touch</td>
<td>2 to 5</td>
</tr>
<tr>
<td>B</td>
<td>Preganglionic autonomic</td>
<td>&lt;3</td>
</tr>
</tbody>
</table>

**Table II.** Number and percentages of different types of nerve fibre within the spinal accessory nerve

<table>
<thead>
<tr>
<th>Spinal accessory nerve section*</th>
<th>Upper</th>
<th>Middle</th>
<th>Lower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Total number of nerve fibres counted</td>
<td>252</td>
<td>280</td>
<td>172</td>
</tr>
<tr>
<td>Diameter of myelinated nerve fibres in µm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A(\alpha) &gt; 12</td>
<td>95</td>
<td>89</td>
<td>72</td>
</tr>
<tr>
<td>A(\beta)  6 to 12</td>
<td>11</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>A(\gamma) 3 to 6</td>
<td>7</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>A(\delta) 1 to 3</td>
<td>6</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Diameter of unmyelinated nerve fibres in µm</td>
<td>32</td>
<td>53</td>
<td>158</td>
</tr>
<tr>
<td>C &gt; 2</td>
<td>133</td>
<td>48</td>
<td>75</td>
</tr>
</tbody>
</table>

* The terms ‘upper section’, middle section and ‘lower section’ refer to the samples of spinal accessory nerve obtained from the jugular foramen, adjacent to sternocleidomastoid, and just before entry into trapezius, respectively.
Another area of interest is the pain experienced after iatrogenic injury to the nerve. The spinal accessory nerve is susceptible to injury because it is small (<2 mm diameter) and has a long course across the posterior triangle of the neck where it is intimately related to many sets of lymph nodes. The clinical consequences of division of the spinal accessory nerve are numbness, paralysis of the trapezius, pain and an alteration in shoulder biomechanics.1

Pain is the most serious and common complication of injury to the nerve and is significant in 65% of patients.18 The accepted theory of the cause of this pain is traction secondary to the drooped shoulder.2,4,19 After nerve grafts or neurolysis of the nerve in iatrogenic injury, there is often improvement in the pain, but the shoulder droop remains.18 This implies that there may be a neuroma at the site of injury and therefore the presence of nociceptive fibres within the injured nerve.

The cause of the pain, particularly in the area of the trapezius, after ‘whiplash-associated’ injuries, is poorly understood.20 A hypothesis suggested by our results is that there is an injury to the accessory nerve (e.g. traction injury) with the formation of a neuroma resulting in the pain.

It is interesting that the spinal accessory nerve is known to develop as a mixed nerve, but is thought to lose its sensory cells by their migration into the dorsal roots of adjacent cervical nerves.19 The current edition of Gray’s anatomy21 states that the assumption that the spinal component of the accessory nerve is purely motor is almost certainly incorrect and refers to Pearson’s findings of sensory ganglion cells in the embryonic nerve.22 Brodal23 also refers to these observations and to the fact that the spinal accessory nerve contains afferent fibres. He suggests that these fibres have a sensory function in accordance with the experiments of Windle24 who demonstrated unipolar ganglion cells on the intracranial portion of the nerve in man. These cells were seen to undergo retrograde changes after section of the nerve. He also refers to the presence of sensory fibres in the spinal nerves which join the spinal accessory nerve, and cites the physiological experiments by Yee et al14 which implied that these fibres were proprioceptive in nature.

Finally, it is of note that recent research in adult rats has identified sensory nerve fibres and ganglia consistently associated with the spinal accessory nerve in adults which provide a nociceptive function.24,25 The results of our study suggest that the composition of the nerve is similar in man.

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References