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Cranial Nerve Injuries After Carotid Artery Surgery. A Prospective Study of 663 Operations

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Objective: *To establish the incidence of cranial nerve injuries caused by carotid artery surgery.*
Methods: *During the years 1982 to 1992, 689 carotid artery operations were performed at Malmö General Hospital. Of these 656 were pre- and postoperatively examined at the Department of Phoniatrics concerning the function of the cranial nerves IX, X, and XII.*
Results: *There was injury to one or more of the examined nerves after 75 operations (11.4%). In 70 (10.7%) operations the hypoglossal nerve was injured, in eight (1.2%) the recurrent laryngeal nerve, in two (0.3%) the glossopharyngeal nerve and in two (0.3%) the superior laryngeal nerve. Seven patients complained of postoperative hoarseness, but had no injuries. One hypoglossal and one recurrent nerve injury was permanent. Nerve injury was more frequent in operations performed with a shunt ($p = 0.05$), with patch closure ($p = 0.01$) and by a junior surgeon ($p = 0.05$).*
Conclusion: *In a prospective series, the incidence of cranial nerve injuries after carotid surgery was significant but the vast majority were reversible.*

Key Words: Carotid artery surgery; Cranial nerve injury.

Introduction

Surgery in the neck region requires special care and caution in order to avoid local nerve damage. In carotid artery surgery the main focus of interest has been the frequency of perioperative stroke and myocardial infarction while local nerve damage has attracted much less attention. Prospective studies are few and involve few patients.[1]

The aim of this study was to prospectively establish the frequency and the cause of cranial nerve damage following carotid artery surgery in a large population.

Material and Methods

During the years 1982 to 1992, 689 carotid artery operations were performed at Malmö University Hospital. The median age of the patients was 65.8 years (range 33–84), 72% were males. Of these 656 (95.4%) had pre- and postoperative examination of the IXth, Xth, and the XIIth cranial nerve function. Twelve of the patients were not examined postoperatively because of early postoperative mortality and another 20 were not examined for various reasons such as unwillingness to cooperate, urgent and emergency operations or a carotid operation in connection with another operation.

Pre- and postoperative examinations were made at the Department of Phoniatrics, dealing with disorders of speech, the day before surgery and before discharge from the hospital or within the first postoperative month. The patients were examined with voice recordings and stroboscopic light examination of the vocal cords as well as a clinical examination of the nerves described above. Pathological changes were followed up until recovery. Standards for classification according to Baker *et al.*[2] were used.

Most operations were performed under general anaesthesia with controlled respiration and normocapnea. After induction with sodium pentothal anaesthesia was maintained with isoflurane. In 49 cases local anaesthesia with regional nerve block and local infiltration was used. The carotid artery was exposed through an incision parallel and anterior to the sternocleidomastoid muscle. The faciolingual vein

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crossing anterior to the carotid bifurcation was divided, and the artery dissected free. The hypoglossal nerve was identified and the ansa cervicalis was divided when necessary. Usually, an Adson type of retractor was used in a ventro-dorsal direction and the cranial part of the internal carotid artery (ICA) was exposed with a hand held Langenbeck retractor.

During the study period, shunts became used more frequently and from 1984–1985 a Pruit-Inahara shunt was inserted after systemic heparinisation in most patients with a preoperative minor stroke. In the remaining patients a shunt was inserted if the stump pressure was < 25 mmHg in TIA patients, and < 50 mmHg in minor stroke patients. The arteriotomy was closed with a patch when the ICA had a small calibre, when it was kinked, if there were technical difficulties or after reoperation for a suspected early thrombosis. In 634 operations a standard endarterectomy of the ICA was made, 14 operations were performed on the external carotid artery (ECA), in two operations the artery was exposed but no endarterectomy was made and on three occasions the stenosed segment was resected. Junior surgeons were defined as surgeons with less than 3 years experience of carotid artery surgery.

Statistics

Data were collected and processed on a personal computer and statistical calculations were made using the SPSS program. Chi square, Fisher's exact and Students T-test were used when appropriate. The null hypothesis was rejected when $p < 0.05$.

Results

Twelve patients died within 30 days (1.7%), six from myocardial infarction, five from major stroke and one from suicide. Thirty-four patients had a permanent minor stroke (4.9%), 12 patients had a reversible stroke (1.7%) and 28 had a brief stroke (4.1%) within 30 days. No patient had a preoperative injury of the examined nerves.

There were injuries in one or more of the examined nerves after 75 (11.4%) of the 656 operations. After 69 operations there was damage to one nerve, after five damage to two nerves and after one operation, damage to three nerves (Table 1). Seven patients complained of postoperative hoarseness but had documented no nerve injury. In four of these cases, haematoma of the vocal cords or the laryngeal wall was noticed, in one a vocal cord granuloma was found and in two patients no pathologic findings were observed. One patient had a permanent hypoglossal nerve injury (> 1 year) and one had a permanent recurrent nerve injury (> 6 months). The remaining cranial nerve injuries recovered within 6 months, and usually within 4–6 weeks. Two patients had a hypoglossal injury on the contralateral side.

Table 1. Frequency of nerve injuries

Nerve	Number	%
Hypoglossal	70	10.7
Recurrent	8	1.2
Glossopharyngeal	2	0.3
Superior laryngeal	2	0.3
Total	82	12.5

When nerve injuries were analyzed according to preoperative symptoms, type of operation, dissection of the hypoglossal nerve, postoperative neurological or local complications such as postoperative haematoma or reoperation for bleeding, age, body mass index and complicating diseases such as diabetes, hypertension or coronary artery disease, no difference was found. In the following categories nerve injuries were more frequent:
In patients operated with a shunt ($n = 207$ 15.0 *vs.* 9.8% $p = 0.05$ relative risk 1.6 95% CI 1.0–2.7), in patients where the vessel was closed with a patch ($n = 87$ 21.8 *vs.* 9.8% $p = 0.01$ relative risk 2.6 95% CI 1.4–4.6) and in patients operated by a junior surgeon ($n = 112$ 16.1 *vs.* 9.6 $p = 0.05$ 95% relative risk 1.8 CI 1.0–3.2). A cofactor for the two latter categories was clamping time which was significantly longer in both groups (for patch 25 min *vs.* 36 min $p < 0.001$ and for surgeon category 25 *vs.* 31 min $p < 0.01$). Clamping time itself had no influence on nerve injury. When operations were analyzed according to year of operation a significant variation of nerve injuries was found ($p < 0.05$, Fig. 1).

Apart from the prospectively examined nerves, two reversible injuries to the marginal ramus of the facial nerve, two reversible injuries to the cervical sympathetic chain and one injury to the accessory nerve with only partly restored function after 1 year were noticed.

Discussion

The area surrounding the carotid bifurcation has a very complex anatomical structure. Therefore it is not

surprising that injuries to the nerves are common after carotid artery surgery. A detailed knowledge of the surgical anatomy of the area and meticulous surgical technique will help to prevent this annoying morbidity in an otherwise successful carotid operation.

Injuries to the peripheral nerves have been less frequently studied than other complications in carotid artery surgery, especially in prospective studies. Reported frequencies of injuries vary from 3–80%.[3,4] There are several reasons for these variations. Retrospective studies tend to under- or overestimate the number of injuries. This is most often the case in damage to the vagus branches and the glossopharyngeal nerve. Careful examination of the laryngeal and pharyngeal function pre- and postoperatively is the only way to accurately assess the function of these nerves.[5] Some investigators include damage to the superficial sensory nerves and some do not. One obvious reason for this variation is that the frequency of these injuries is probably quite high. Standards for reporting injuries vary, and some investigators use the number of damaged nerves in relation to the number of operations as a measure while others use the number of patients with injuries. Since multiple injuries are not uncommon this may have an influence on results.

The hypoglossal nerve is, for anatomical reasons, the most commonly affected cranial nerve in carotid artery surgery and earlier prospective studies have shown frequencies from 5–20%.[6–8] The resulting paresis of the ipsilateral muscle of the tongue will cause problems in mastication and speech, while bilateral injury may cause life threatening airway obstruction.[9] Injuries to this nerve have been reported as seldom being permanent and usually with restored function within 4–6 weeks, but in the reports by Weiss *et al.*[10] and Astor *et al.*[11] up to 30% of the injuries were permanent. According to our experience this nerve injury is reversible in the vast majority (69 out of 70). The vagus nerve and its branches, especially the recurrent laryngeal nerve, is the second most affected nerve. Damage will result in ipsilateral vocal cord paralysis. Postoperative malfunction has been reported in 35% by Evans *et al.*[12] while frequencies up to 6% are more common in other prospective studies.[4,6,8] Injuries to the superior laryngeal nerve are less frequent and also harder to detect. Damage will result in paralysis of the cricothyroid muscle with subsequent loss of high pitched tones and phonastenia, which may be particularly troublesome for singers and patients who use their voice professionally. Frequencies around 1% are reported in prospective studies.[4,6,8] The glossopharyngeal nerve is not normally exposed in the surgical wound, and this is reflected in the number of injuries described in the literature. Since this nerve provides sensory fibres for

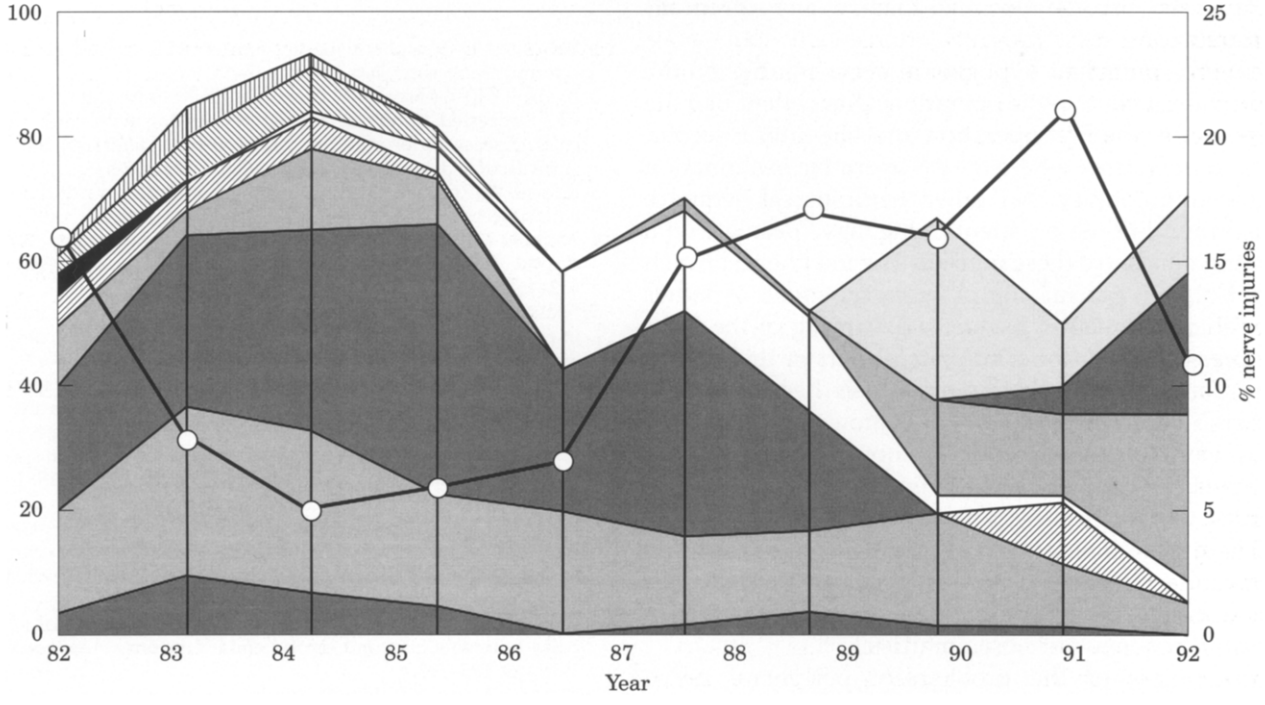

Fig. 1. Nerve injuries related to year of surgery and operations/year/surgeon. Each field in the diagram represents operations made by one surgeon. Black line represents annual incidence of nerve injuries.

taste and sensation to the posterior one-third of the tongue and pharyngeal mucosa as well as motor fibres to velar and pharyngeal elevators, damage will result in uvula deviation from the affected side and difficulties in swallowing. Frequencies of around 1% have been reported by Evans *et al.*[12] and by Forssell *et al.*[8]

In this study we found that injuries were related to use of a shunt, patch closure and operations by junior surgeons. There were also signs of variations in time (Fig. 1) suggesting the existence of a "learning curve", or in this case two curves with set points at the start of the study and in 1987, when a new generation of surgeons started to perform a greater number of the operations. The critical factor influencing the number of nerve injuries seems to be the clamping time, which was the common factor in the junior surgeon group and the patch group. The clamping time itself is probably not the critical factor but rather the time from arteriotomy to completion of the suture line, which was not measured in this study. The reason for this assumption is the fact that shunted patients had more injuries. The use of an indwelling shunt increases the time when the wound is traumatized by retractors, whereas the clamping time itself is very short. A further support for this hypothesis is that the clamping time had no relation to the number of injuries. This was probably caused by a skew sampling, where operations with an injury more often were performed using a shunt and thus when the analysis was made without shunted patients, the sample size became too small to show any significant difference.

Two patients had hypoglossal nerve injuries on the side contralateral to the operation. One patient had the injury after the first operation and one after a second staged operation, where the preoperative examination showed no injury. No other neurological sequelae were found in these patients. One may speculate on a central genesis of these injuries. The likelihood of such an isolated central injury is very small. Another possible explanation is extensive turning of the head or pressure from the contralateral part of the mandible. Contralateral nerve injuries have been found by others[13] but in those cases subluxation of the mandible was performed in order to obtain access to an arteriosclerotic plaque extending to the base of the skull. Other studies involving subclavian-carotid bypass, resection and additional procedures other than endarterectomy with a longer period of potential nerve traction and compression have also shown a greater frequency of nerve injuries.[14–16]

Awareness of the problem of peripheral nerve injuries is important as these injuries can be avoided to a great extent if certain measures are taken. A detailed knowledge of the surgical anatomy is essential for the surgeon as well as the assistant. Careful handling of tissues and an atraumatic surgical technique with sharp dissection close to the arterial wall will lessen this risk. Retractors must be placed with great care not to stetch the nerves and special care should be taken not to place them too deep in the tracheoesophageaal grove or to pull too hard and constantly on retractors held in the cranial part of the wound. Precise bipolar electrocautery and carefully placed ligatures are important parts of the surgical technique and special attention should be taken to the small vessels "tethering" the hypoglossal nerve. If bleeding occurs at this point, these vessels should not be grasped blindly with clamps. The hypoglossal nerve should be identified and if necessary carefully dissected away after division of the ansa cervicalis. If the digastric muscle has to be divided it must be borne in mind that the glossopharyngeal nerve is at risk of injury.

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