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ORIGINAL ARTICLE

Carotid body tumour resection with LigaSure® device

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KEYWORDS
Carotid body tumour;
Surgical resection;
Operative complications;
LigaSure®

Abstract
Objective: We carried out this study in patients who underwent resection of carotid body tumour (CBT). Shamblin's classification system was used, as well as the modified Shamblin classification. We sought to determine whether surgical time and bleeding could be reduced with the use of the LigaSure® system.
Methods: A prospective study was carried out in patients with CBT.
Results: A decrease in both time and bleeding was shown, although only overall time showed statistical significance. Cases were classified as Shamblin I, II and III in two, six, and four cases, respectively, and after surgical treatment were classified as modified Shamblin I, II, IIIa and IIIb in two, one, and six cases, respectively, by infiltration to the carotid. There was nerve damage in four cases, and there were three carotid resections.
Conclusions: Use of LigaSure® decreased bleeding and surgical time in CBTs. Lesions of the artery are mainly caused by infiltration or by muscular hypotrophy of the artery, which frequently requires vascular reconstruction. Nerve injury continues to be an important postoperative complication, which may result in a reduction in the quality of life for the patient. The rates of nerve injury as a result of surgery were unchanged.

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PALABRAS CLAVE
Tumor del cuerpo carotideo;
Resección quirúrgica;
Complicaciones operatorias;
LigaSure®

Resección de tumor de cuerpo carotídeo con LigaSure®

Resumen
Objetivo: Realizamos este estudio en pacientes a quienes se les realizó resección de tumores del cuerpo carotídeo (TCC). La clasificación de Shamblin fue usada, así como también la clasificación de Shamblin modificada. Tratamos de determinar si el tiempo quirúrgico y el sangrado podrían ser disminuidos con el uso de LigaSure®.
Métodos: Se realizo un estudio prospectivo en pacientes con TCC.
Resultados: Se muestra una clara disminución en ambas cifras, tiempo y sangrado; sin embargo, las diferencias sólo fueron estadísticamente significativas para el tiempo. Se encontraban en Shamblin I, II y III, 2, 6 y 4 casos, respectivamente, y tras el tratamiento quirúrgico la clasificación Shamblin varió a I, II, IIIa y IIIb en 2, 1, 1 y 6 casos, respectivamente, por infiltración a la carótida.
Conclusiones: El uso de LigaSure® disminuye el sangrado y el tiempo quirúrgico en los TCC. Las lesiones de la arteria son principalmente causadas por infiltración o por hipotrofia de la muscular de la arteria, que frecuentemente requieren reconstrucción vascular. Las lesiones nerviosas continúan siendo una complicación postoperatoria importante que puede provocar una disminución en la calidad de vida de los pacientes. La tasa de lesiones nerviosas como resultado de la cirugía permanece sin cambios.

Introduction

In 1977, Lack et al. estimated that head and neck paragangliomas represent 0.012% of all human tumours.[1] Of these, 45% correspond to carotid body tumours (CBT).[2] These neoplasms originate from the carotid body chemoreceptors and baroreceptors. CBT are normally treated by surgical excision. The scope of the procedure varies depending on the degree of involvement of surrounding structures (that is, carotid arteries, skull base and vagus nerve). The reduction of intraoperative bleeding has always been one of the main objectives of the resection of CBT. The effort to control bleeding may prolong surgical time, placing at risk the surrounding organs. The use of the vascular sealing system Ligasure® (Valleylab, Boulder, CO) can help to reduce bleeding, while reducing surgical time. Ligasure® is an electrothermal sealing system that seals the vessel through physical pressure and bipolar electrical coagulation, reducing thermal spread. Ligasure® is a new technology that can also be applied during certain surgical situations. In head and neck surgery, it can also be applied in only two conditions: malignant parotid tumours and thyroidectomies.[3-6] However, there is no documentation on its use in CBT. We attempt to find out its advantages and disadvantages to determine whether operative time and bleeding could be reduced with the use of the Ligasure® system in the surgical treatment of CBT.

Materials and methods

A prospective study was conducted from September 2004 to May 2007 in patients with CBT. All the patients required medical care due to the presence of a cervical mass. A clinical diagnosis was performed and confirmed through computed tomography and/or magnetic resonance imaging, angiotomography and angioresonance. None of the patients underwent preoperative angiography or embolisation. The patients had no family history of CBT.

Table 1 Proposed modification of the classification by Shamblin[a]

Shamblin	Size	Surrounding Carotid Vessels	Excision
I	<4 cm	No	No difficulty
II	>4 cm	Partially	Difficult
IIIa	>4 cm	Narrowly	Difficult
IIIb=I, II, or III infiltration in any carotid vessel	Any size		Requiring vascular sacrifice or vessel substitution, but intramural invasion should be confirmed clinically and/or histologically

[a]Luna-Ortiz K, Rascon-Ortiz M, Villavicencio-Valencia V, Herrera-Gomez A. Does Shamblin's classification predict postoperative morbidity in carotid body tumors? A proposal to modify Shamblin's classification [errata in Eur Arch Otorhinolaryngol. 2006;263:1161]. Eur Arch Otorhinolaryngol. 2006;263:171-5.

Figure 1 Shamblin's classification and proposed modification, in which Shamblin III is subdivided into "a" or "b", where "a" is as described originally and "b" includes I, II, or III, the difference being total or partial infiltration. (Luna-Ortiz K, Rascon-Ortiz M, Villavicencio-Valencia V, Herrera-Gomez A. Does Shamblin's classification predict postoperative morbidity in carotid body tumors: A proposal to modify Shamblin's classification [errata in Eur Arch Otorhinolaryngol. 2006,263:1161]. Eur Arch Otorhinolaryngol. 2006;263:171-5.)

CBT resection was performed using Ligasure®. We felt that the Ligasure® Precise system was very useful. The surgery was performed by the same surgical team in all cases. The Shamblin[7] classification was used, as well as the Shamblin classification modified by Luna-Ortiz et al.[8] (Table 1, Figure 1). The results were analysed using descriptive statistics and the non-parametric test of Mann-Whitney U for comparisons between groups.

Technique

An incision was made at the anterior border of the sternocleidomastoid muscle. The deep anterior fascia was dissected towards the sternocleidomastoid to expose the proximal common carotid artery. This is important to achieve early vascular control, because blood supply to the CBT is typically provided by the common and external carotid arteries. The dissection plane was initiated anteriorly in the common carotid artery in the normal vessel wall adjacent to the CBT, extending forward to the carotid bifurcation, identifying the subadventitial plane or "white line" described by Gordon-Taylor[9] to separate the lesion from the artery, with a relatively avascular plane between the tumour and the wall (Figure 2). A meticulous dissection of the vagus and hypoglossal nerves was carried out, avoiding the resection as far as possible.

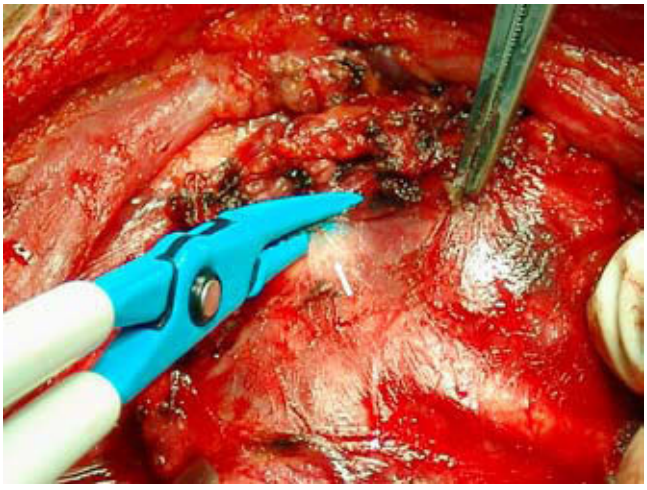


Figure 2 Resection of carotid body tumour with harmonic Ligasure®. The identification of the subadventitial plane (arrow) enables a better dissection of the carotid artery, minimising blood loss.

Results

Resection of the CBT was performed using Ligasure® in 12 cases over a period of 30 months. The cases included 11 women and 1 man, with an average age of 52 years (range: 27-72 years) and an average time of evolution of 64.5 months (range: 3-360 months). The main clinical manifestation was a painless neck mass of slow growth in seven cases on the left side, and five cases on the right side. The times and the bleeding were generally evaluated by groups, showing a clear decrease in both surgical time and bleeding; however, there was statistical significance only in terms of time, in general, when making the comparison with our series historically[9] (Table 2). Cases were classified as Shamblin I, II and III in 2, 6, and 4 cases, respectively; and after surgical treatment they were classified as Shamblin I, II, IIIa, and IIIb modified in 2, 1, and 6 cases, respectively, by infiltration of the carotid. Nerve injury occurred in four cases (33%), with three carotid resections as shown in Table 3.

Discussion

CBT are neoplasms with a high potential for bleeding during surgery (range 16-3,000 ml). This can result in haemodynamic

Table 2 Shamblin versus modified Shamblin in LigaSure® series

	Historical Shamblin[4] Series	Modified Shamblin	*P*	CI (95%)
	Average (range) (n=48)	Average (range) LigaSure® (n=12)		
	All	All		
Time	233 min (SD) (78)	169 min SD (70)	.01	14.79 to 114
Blood loss	586 cm^3 (SD) (646)	285 cm^3 SD (398)	.13	−13.4 to 615
Time	I, II	I-IIIa	.07	−15 to 108
	233 min (90-315)	145 min (90-220)		
	III	IIIb	.07	−6.69 to 138.5
	278 min (150-435)	193 min (50-290)		138.5
Blood loss	I, II	I-IIIa	.14	4.17 to 268
	258 cm^3 (25-900)	121 cm^3 (50-300)		
	III	IIIb	.23	−182.3 to 993.7
	909 cm^3 (200-3,000)	450 cm^3 (200-1,500)		

CI: confidence interval; SD: standard deviation.

Table 3 Demographics, characteristics and blood loss, complications and nerve damage

Case	Shamblin (Shamblin Modified)	Blood Loss (cm^3)	Complications and Management	Intraoperative Nerve Lesions
1	II (IIIb)	300	Infiltration of ECA	Nerves X and XII
2	III (IIIb)	200	Infiltration of ECA	No
3	II (II)	80	No	No
4	I	50	No	No
5	II	100	ICA and ECA skeletonized	No
6	II	300	No	No
7	II (IIIb)	300	Infiltration of CA	Nerve X
8	IIIa (IIIb)	1,500	Infiltration of ECA, resection bypass	Nerve X
9	III (IIIa)	10	No	No
10	I	150	No	No
11	III (IIIb)	10	Infiltration of ICA ECA Transposition	No
12	II (IIIb)	350	Infiltration of ICA+resection and bypass. Resection of the glomus of the vagal nerve	Nerve X

ECA: external carotid artery; ICA: internal carotid artery.

shock and even death, as well as vascular damage directly associated with neoplasms by infiltration into the wall of the carotid artery with its various branches, including a required vascular sacrifice of 28% and 6.3% of vascular reconstruction, as we reported previously in our institution.[8,10] Because of this situation, some authors support the use of preoperative embolisation as initial treatment prior to definitive surgical treatment.[11] At our institution, we have chosen not to use preoperative embolisation in CBT resection. We are aware of two possibilities of bleeding during surgery. The first and least serious is bleeding from the carotid body tumour itself, where embolisation could be meaningful. However, we are aware that 100% embolisation cannot be achieved because the vascularity may originate from the carotid artery itself or from the vertebral artery—the latter being unusual—as well as the possibility of opening the collateral circulation of the carotid body. That is the best location for the application of Ligasure®. The Ligasure® system is a bipolar diathermy system that achieves vessel sealing with a reduction of thermal spread at a temperature of <100 ºC in the tissue,[12] with a peripheral spread of energy of full thickness of 4.5 mm for the artery and 6.3 mm for the veins. This system is superior to the other devices tested, in terms of vascular sealing capacity of up to 7mm.[13]

The second cause of bleeding during surgery is directly related to CBT alterations in the carotid artery (common, internal or external). These alterations have two causes. The first of these has been described previously by Luna-Ortiz et al.[8] when these authors histologically confirmed the disappearance of the avascular line as a plane of dissection, as described by Gordon-Taylor.[9] This was replaced by hypocellular connective tissue with abundant collagen. This fibrous tissue extends from the septum and the capsule of the tumour to the adventitia of the artery. The fibrosis may

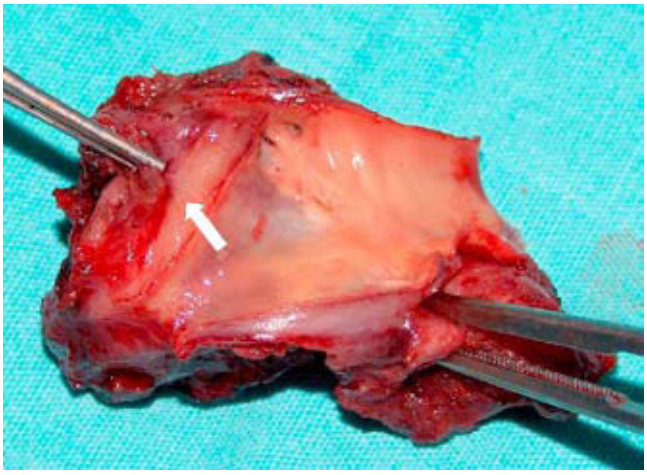


Figure 3 The common carotid artery and its two branches are observed carrying out a longitudinal cut, since it adheres to the carotid body tumour in its wall, without a plane of dissection being identified (arrow).

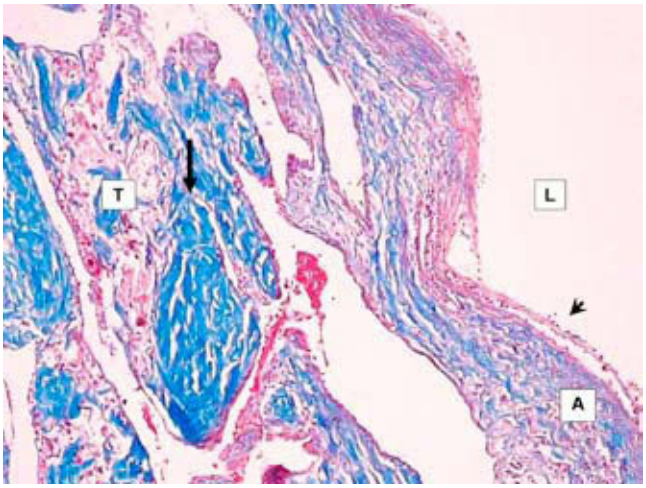


Figure 5 The tumour has large areas of sclerosis (arrow), although the capsule is thin. Collagen fibres are observed which partially replace the muscular wall of the artery and show its thinning (arrowhead). Trichrome Masson, x 100. A: artery, L: lumen, T: tumour.

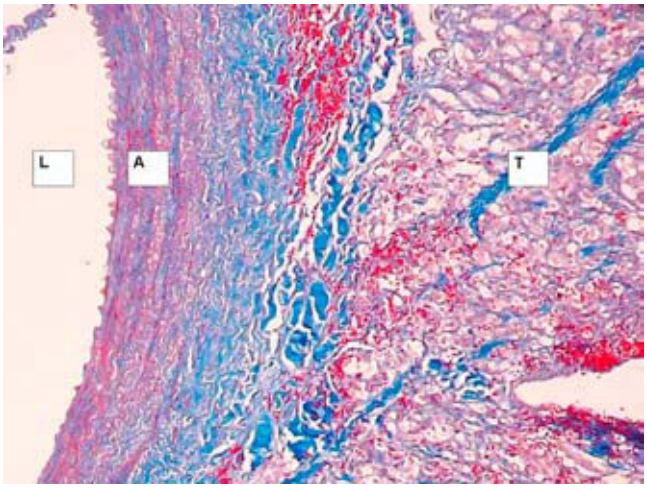
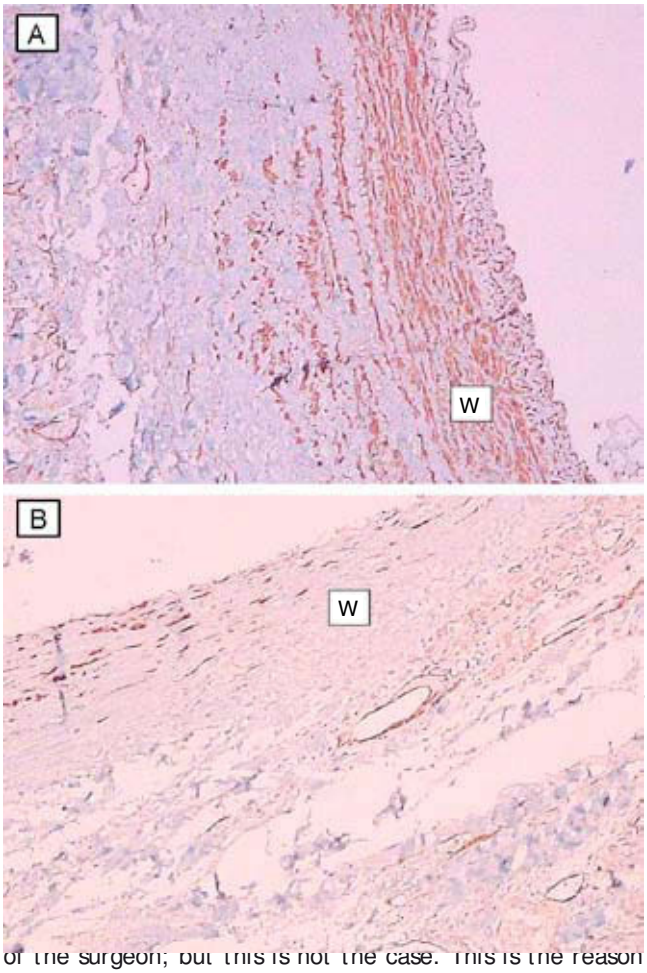


Figure 4 Transition between the arterial wall (left) and the capsule of the tumour (right). There is no clear interface or separation plane. Trichrome Masson, x 400. Blue collagen fibres. A: artery, L: lumen, T: tumour.

be partial and its extent is also related to the Shamblin classification, although it can be present in all grades. For this reason, Luna-Ortiz et al.[8] proposed a modification of the Shamblin classification. However, it is not possible at present to radiologically demonstrate the infiltration of the fibrosis generated around the carotid (Figure 3). This can only be done during surgery and can be definitely corroborated through histopathology. In some cases, it appears that the collagen fibres extend to the vascular layer of the vessel, causing a decrease in thickness and elasticity which, consequently, increases the risk of perforation. The second cause, which has not been mentioned previously, is hypotrophy of the arterial muscles, which makes it even more susceptible to perforation. This muscle hypotrophy means that, clinically, the artery after the removal of the



of the surgeon; but this is not the case. This is the reason

Figure 6 Comparative photograph of the arterial wall using immunohistochemical actin. A) Muscle layer of normal thickness. B) Arterial wall with small smooth muscle fibres that are separated by thick muscle fibres continuing with the tumour capsule. W: arterial wall.

why Ligasure® is mostly suitable for resection of CBT relative to the bleeding caused by the tumour itself, and not to the possible infiltration of the wall of the carotid artery in any of its branches, or in the common carotid artery.

We have reported an average blood loss of 586 ml and an average surgical time of 230 min in the 50 latest CBT resections carried out at our institution using conventional electro-cauterisation.[8] However, we were able to reduce bleeding and surgical time to an average of 285 ml and 169 min, respectively, by performing the surgery with Ligasure®. This represents relevance only in terms of time, possibly due mainly to the small size of our sample. Ligasure® constitutes an excellent aid during CBT surgery, being indicated mainly for Shamblin I and II tumours (original Shamblin classification) and for Shamblin I to IIIa tumours (modified Shamblin classification). In cases where the arterial wall is attached or infiltrated, then partial resection is necessary, as well as vascular transposition or vascular substitution of the carotid artery with synthetic material. The usefulness of Ligasure® is limited or nonexistent.

One option for Shamblin III is based on the proposal of Hurtado-Lopez et al.[14] These authors have demonstrated their experience with the hybrid surgical technique, using endovascular stents. They have shown a decrease of blood loss and surgical time with a minimal possibility of damage to the common carotid artery or its branches, which may require some type of vascular replacement. Prospective studies are needed to identify the benefits of this technique with respect to nerve damage and to evaluate potential complications due to the endovascular procedure "per se". However, they currently offer a promising option.

Nerve injuries were present in this study. Vagus nerve injuries were the most common in four cases (33%), one of which was also associated to lesions of the hypoglossal nerve. In only one case was the resection of the vagus nerve carried out with that of the tumour, due to the impossibility of making a separation. There were other clinical damages, but we were able to conserve the nerve. These nerve lesions may be due to heat damage, being more related with Ligasure® than with the anatomical damages; the peripheral energy spread oscillates between 4.5-6.3 mm, as we have explained previously.[13] However, as we have reported with our experience, nerve injuries represent 49% and do not seem to be related to CBT size. Therefore, with the Shamblin classification, this seems to be due only to the experience of the surgeon.[8] Ligasure® is a safe and effective haemostatic control method that reduces surgical time, although it does not reduce the incidence of complications. The same phenomenon has been reported in thyroid surgery.[15]

In conclusion, Ligasure® decreases bleeding and surgical time in CBT. The arterial lesions are mainly caused by infiltration or muscle hypotrophy of the artery, often requiring a vascular reconstruction. Nerve injuries remain a significant postoperative complication, which can result in a diminished quality of life for patients. The percentages of nerve lesions remain unchanged.

Conflict of interests

The authors declare no conflict of interests.

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