Hemostatic Control with Gelatin Sponge and Quantum Molecular Resonance Coagulation in a Case of Glomus Tympanicum

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ABSTRACT

Surgical removal of tumor is the primary treatment of choice for glomus tympanicum (GT). However, because the tumor has abundant blood flow, bleeding control is crucial, and preoperative embolization may be performed. Here, we report the case of a 46-year-old female who visited our hospital with a complaint of right pulsatile tinnitus. A red pulsatile mass was found in the right tympanic cavity, and she was diagnosed with class B1 GT and subsequently underwent surgical treatment. We judged that bleeding could be controlled by intratympanic cavity manipulation alone and decided to perform transmeatal tumor resection without preoperative arterial embolization. After creating a tympanomeatal flap and performing an atticotomy, some pieces of Spongel® were inserted between the tumor and the tympanic wall. The Spongel® absorbed the blood and created a space between the tumor and tympanic wall, which allowed for the insertion of the tip of the Vesalius® handpiece to coagulate the tumor. The coagulation caused the tumor to shrink, thereby widening the space and allowing for further resection. Although the surgical manipulation caused bleeding, complete resection was achieved by the application of Spongel® and coagulation with Vesalius®. Since the tip of the Vesalius® was not burned, hemostasis was successfully achieved, and the operation proceeded while maintaining a clear field of view. There was little bleeding and no postoperative complications. The patient was discharged on the sixth postoperative day. One year after surgery, pure tone audiometry showed no change in the level of bone conduction. Spongel® and Vesalius® are useful tools that allow to safely perform surgeries even in narrow spaces such as the tympanic cavity.

Key words atticotomy; coagulation; glomus tympanicum; hemostasis

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Abbreviations: CT, computed tomography; GT, glomus tympanicum; MRI, magnetic resonance imaging; QMR, quantum molecular resonance; WI, weighted image

Glomus tympanicum (GT) is a benign tumor arising from the paraganglia of the plexus at the promontory. The tumor is asymptomatic when small but may cause pulsatile tinnitus and conductive hearing loss when it grows bigger.[1] Surgical removal of GT is the treatment of choice. However, because of the tumor's abundant blood flow, surgical treatment may be performed after prior arterial embolization to make bleeding control in a confined space easier. Here, we present a case of GT where we performed a tumor dissection using a hemostatic gelatin sponge (Spongel®, LTL Pharma Co., Ltd., Tokyo, Japan) and a quantum molecular resonance (QMR) coagulation system (Vesalius®, Telea Ing., Vicenza, Italy) to ensure hemostasis. Preoperative arterial embolization was not performed in this case. We also present a discussion of the literature.

PATIENT REPORT

A 46-year-old female patient was aware of right pulsatile tinnitus for approximately 2 years but had neglected it. She had no other relevant medical history. The tinnitus gradually became louder, and the patient first visited a hospital where a red pulsatile mass in the right tympanic cavity was noted, and a GT was suspected. She was directly referred to our hospital for further investigations and treatment. On initial examination in our hospital, a red pulsatile mass was observed through the tympanic membrane in the lower half of the tympanic cavity (Fig. 1a). Computed tomography (CT) of the temporal bone showed an isodense mass in the right hypotympanic cavity with some suspected bone erosion (Fig. 1b). Magnetic resonance imaging (MRI) of the head showed a heterogeneous mass with a low-intensity signal area on T1-weighted image (WI), high-intensity signal area on T2 WI, and relatively strong contrast effect in the area consistent with the CT findings (Fig. 1c). The results of pure tone audiometry showed right-sided conductive hearing loss in the low tone range (Fig. 2a). Blood adrenaline, noradrenaline, and dopamine levels were all within normal limits.

Based on the imaging results, the tumor was considered a class B1 GT according to the Sanna classification.[2] We judged that bleeding could be controlled by intra-tympanic cavity manipulation alone and decided

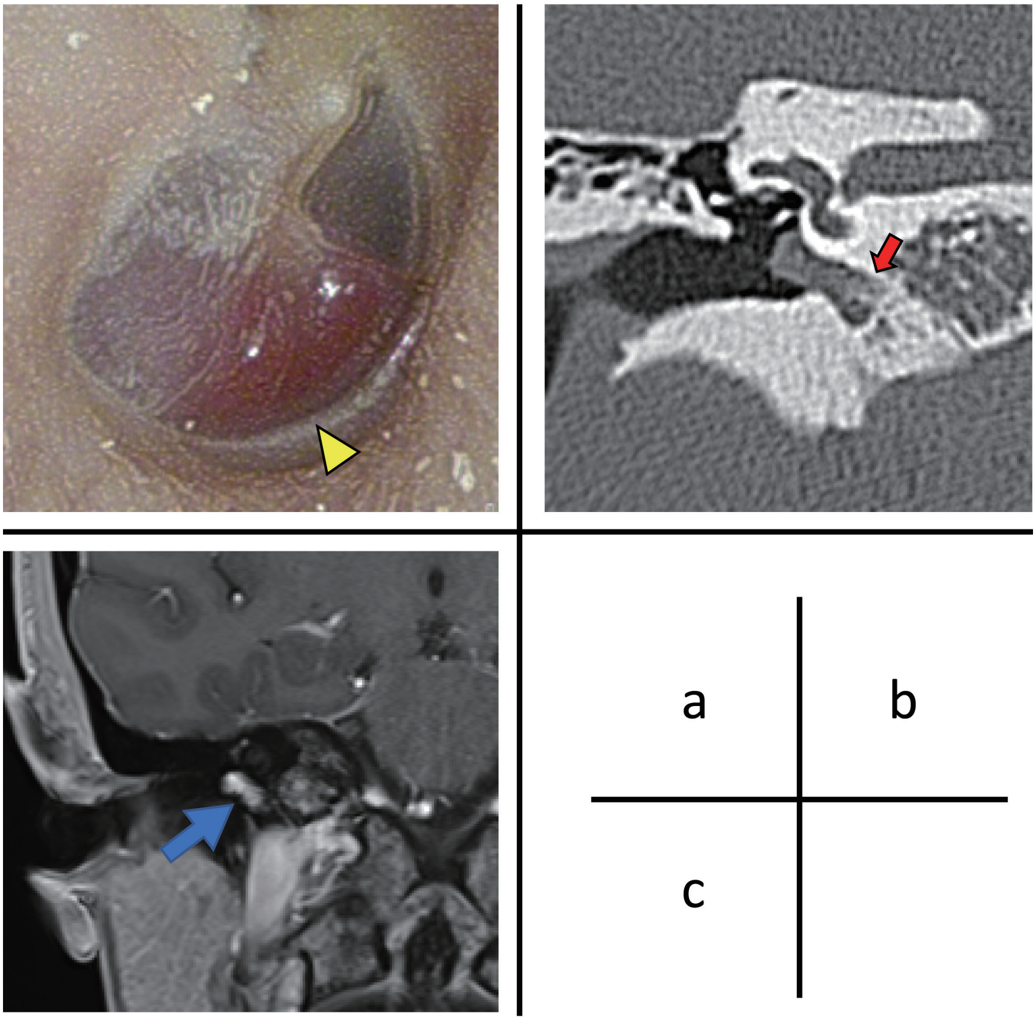

Fig. 1. Findings on physical examination and imaging. **a)** A red pulsatile mass in the lower half of the right tympanic cavity (yellow arrowhead). **b)** Computed tomography image of the temporal bone shows an isodense area with slight bone invasion (red arrow) mainly in the right hypotympanum. **c)** Contrast-enhanced magnetic resonance imaging of the head reveals a mass with relatively strong contrast effect in the tympanic cavity (blue arrow).

to perform transmeatal tumor resection without preoperative arterial embolization. After general anesthesia, a posterior auricle incision was made to create a tympanomeatal flap. The tumor was large and extended from the middle of the tympanic cavity to the hypotympanic area, which resulted in the handle of the malleus being pressed outward (Fig. 3a). After atticotomy and separation of the incudostapedial joint, some compressed and cut Spongel® were inserted between the tumor and the tympanic wall. The expansion of the Spongel® absorbed the blood and created a space between the tumor and tympanic wall, which allowed for the insertion of the tip of the Vesalius® handpiece. The Vesalius® was set to 40 W output to coagulate the tumor. This procedure caused tumor shrinkage, thereby widening the space and allowing for further resection (Fig. 3b). Although the surgical manipulation caused bleeding, complete resection was achieved by the application of Spongel® and coagulation with Vesalius®. Since the tip of the Vesalius® was not burned, hemostasis was successfully achieved, and the operation proceeded while maintaining a clear field of view. The tumor had extended to the infracochlear air cell, which resulted in additional drilling in the direction of the hypotympanic cavity. We found a tumor-feeding vessel running parallel to the Jacobson nerve, which was thought to be the inferior tympanic artery branching from the ascending pharyngeal artery. This artery was cauterized with Vesalius®, and the tumor was resected (Fig. 3c). The surgery was completed with type IIIc ossicular chain reconstruction with the incus (S1A4MxExOx-A1T2Ost in SAMEO-ATO system).[3] The amount of blood loss was < 10 mL. The patient did

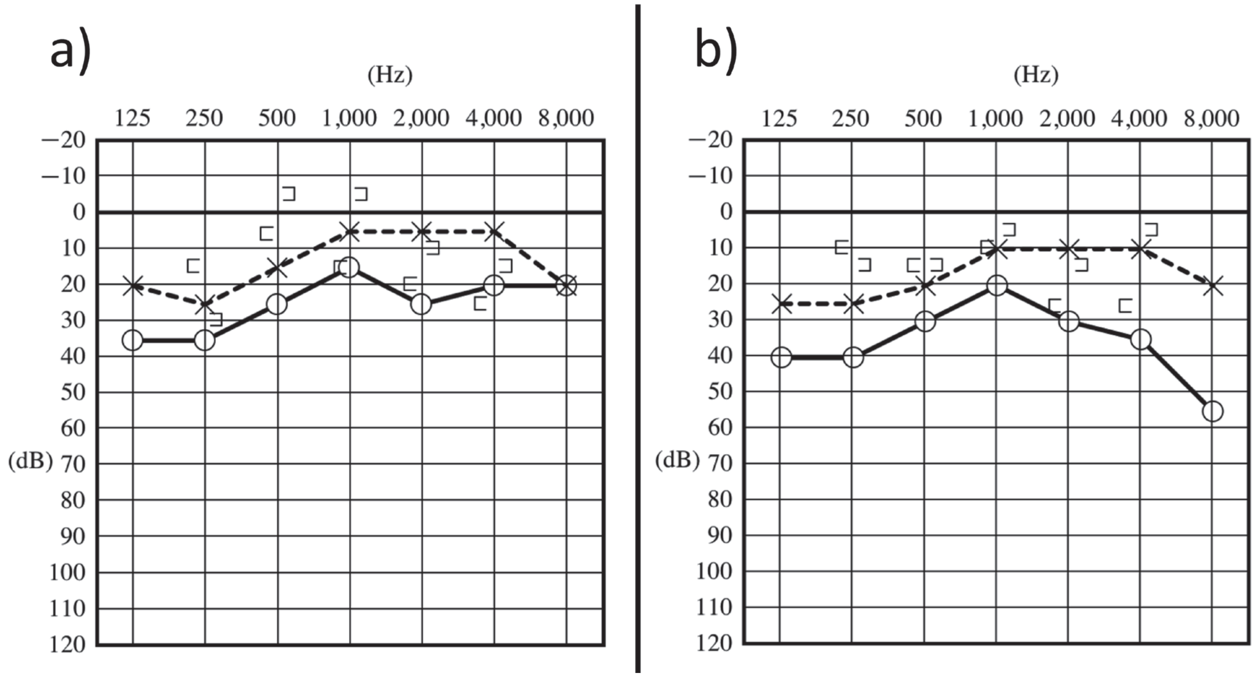

Fig. 2. Audiogram of the right ear pre- and 1–year post-operation. **a)** Low–tone conductive hearing loss in the right ear prior to the operation. **b)** The hearing threshold in the right ear is almost unchanged 1 year after the operation, excluding the level observed at 8 kHz.

not experience facial palsy or dizziness and was discharged on the sixth postoperative day. One year after surgery, pure tone audiometry showed some residual air-bone gap but no increase in bone conduction hearing level (Fig. 2b).

DISCUSSION

GT is a benign, vascular-rich tumor arising from the paraganglia along the Arnold and Jacobson nerves that form the plexus of the promontory,[4] and the most common treatment for these tumors is complete surgical resection.[5] However, tumor resection is associated with challenges in hemostasis because the tumor has abundant blood flow, and the surgery is performed in the narrow bony tympanic cavity. Most intraoperative hemostatic manipulations are performed using energy devices, generally bipolar devices.[6] Conventional bipolar devices heat the surrounding tissue to 150–400°C, which increases the risk of extensive necrosis due to these extreme temperatures and may lead to secondary tissue damage.[7] Moreover, the carbonized tissue may adhere to the tip of the handpiece, resulting in interference with cauterization and the need for cleaning the tip, thus interrupting the hemostasis procedure.

The QMR coagulation system (Vesalius®) used in this case is an electronic device that cuts and coagulates by generating a high-frequency alternating current. The handpiece is the same type as the conventional bipolar device and can be operated in the same manner. The QMR is based on the fundamental principles of quantum theory and generates frequencies that resonate and break the molecular boundaries while keeping the surrounding tissue at a low temperature.[8] When a quantum of energy hits a tissue transmitting the same value of the tissue's bond energy, the bond breaks without an increase of kinetic energy and thus without an increase in temperature as high as that of conventional electro coagulators. By combining different frequencies from 4 to 16 MHz, the QMR generator has the particular effect of inhibiting molecular cell binding and selectively breaking the involved tissue, thereby preventing damage to the surrounding healthy tissue.

In addition, Livatditis et al.[9] explained what happens when a high-frequency current is applied to soft tissue: 1. When the temperatures are sustained beyond 45°C, coagulation of the protein contents of cells occurs. However, the tissue or cellular form remains intact. 2. When tissue temperature rises above 60°C, the water content of the cell is driven out and the process of desiccation begins. Desiccation type of coagulation is considered the optimal endpoint for thermal tissue destruction and hemostasis without long-term adverse effects.

The coagulation function of Vesalius® is achieved by protein denaturation of fibrinogen at 63°C. These are lower temperatures than those traditionally produced by other electromedical devices (such as electrosurgery,

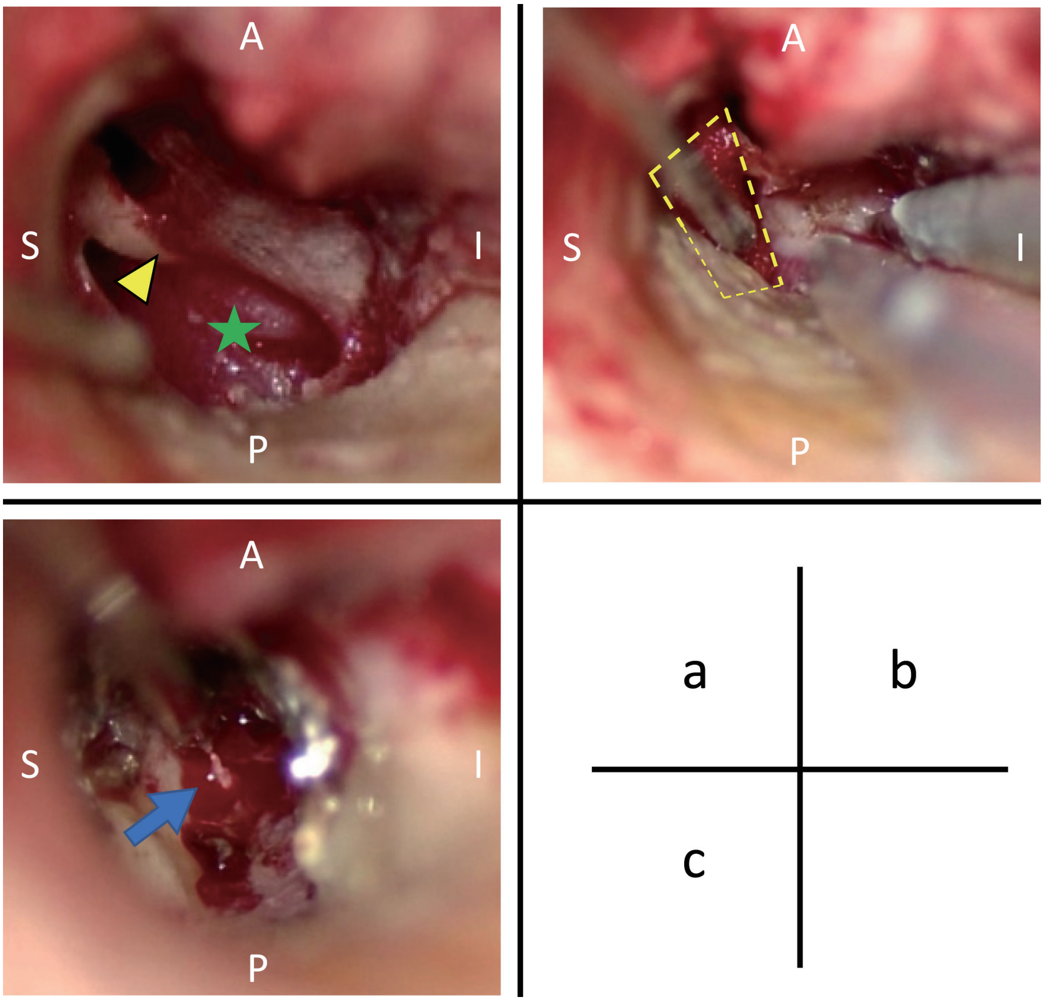

Fig. 3. Intraoperative findings. **a)** Location of the tumor relative to the malleus handle. Yellow arrowhead: malleus handle, green star: tumor. **b)** Spongel® (the area enclosed by the yellow dotted line) was inserted into the tympanic cavity, and the tumor surface was cauterized with Vesalius®. **c)** Blue arrow: inferior tympanic artery. A, anterior; I, inferior; P, posterior; S, superior.

800°C), thus eliminating the need for thermal evaporation and facilitating the physiologic coagulation cascade without the need to create a necrotic plug.[10, 11] Therefore, there is less necrosis of the coagulated tissue and the effect can be localized.[12] In addition, the cauterization shrinks the tumor tissue, thus increasing the working space. A pathological study by Schavon et al. on the state of tissues after coagulation with classical electrocautery and the Vesalius® set at 40 W showed that classical electrocautery resulted in irreversible cell death due to both direct tissue damage and heating, leading to more severe tissue damage than that after the use of Vesalius®.[12] This severe tissue damage may increase the risk of hemorrhage and have a negative impact on the surrounding critical structures. As such, Vesalius® may be better suited for operations in the narrow tympanic cavity, where the field of view is limited.

Hemostatic gelatin sponges are routinely used as materials for closure of eardrum perforation and as packing material of the external auditory canal following middle ear surgery.[13] Spongel®, a type of sponge, is a 2.5 × 5 cm rectangular-shaped sponge that can be compressed or cut to be easily inserted into the appropriate site. It can absorb more than 30 times its weight in water, and when applied to the wound, it can absorb and adhere to blood, thereby reducing bleeding. The advantages of using Spongel® are three-fold: 1) it can be inserted into the gap between the tumor and the tympanic wall; its expansion after absorbing the blood will further enlarge this gap, 2) bipolar coagulation can be performed from the surface of the Spongel®, and 3) Spongel® can be attached to the bleeding site to control bleeding. Thus, Spongel® is a useful material as a universal spacer that can widen the operable range of the handpiece tip and also control bleeding.

In our case, the tumor not only filled the middle tympanic cavity but also extended into the hypotympanum and partially invaded the bone, corresponding to class B1 of the Sanna classification.[2] Although canal wall up tympanomastoidectomy and opening of the posterior tympanic cavity are recommended as treatment strategies for this condition, the procedure creates a blind operation site in the posterior and hypotympanum areas.

In some cases, if the tumor size is large, embolization may be considered for bleeding control.[14] Although there is no consensus regarding the indications for preoperative embolization of the head and neck paragangliomas until now, previous literature clearly indicates that embolization is not recommended for Fisch class A tumors (Sanna class A1, A2)[2] because the risk of potential complications of this invasive procedure does not outweigh the advantages.[14, 15] The tumor size in this case was class B1, which may have been an indication for preoperative embolization. However, we were able to resect the tumor using only a transmeatal approach. In our case, the tumor had only eroded the bony surface, and mastoidectomy was not necessary because Vesalius® and Spongel® use allowed adequate visibility of the operating field. We were able to identify the tumor-feeding artery branching from the inferior tympanic artery. Coagulation hemostasis was accurately performed, and no postoperative bleeding occurred. In addition, total removal of the tumor without embolization was possible with minimal blood loss, thus avoiding the associated physical and financial burden on the patient. The use of Spongel® and Vesalius® may have also contributed to reduced surgeon stress and less surgical invasion.

In conclusion, we safely performed total resection of a GT using a transmeatal approach without arterial embolization. The use of hemostatic gelatin sponges during tumor resection and the use of a QMR coagulation system are important and useful tools in interventions such as otologic surgery, where operations may be performed in narrow and tight areas.

The authors declare no conflict of interest.

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