

## PERSISTENT STAPEDIAL ARTERY: DOES IT PREVENT SUCCESSFUL SURGERY?

PAUL J. GOVAERTS, MD

ANTWERP, BELGIUM

THÉRÈSE F. MARQUET, MD

ANTWERP, BELGIUM

COR W. R. J. CREMERS, MD, PHD

NIJMEGEN, THE NETHERLANDS

F. ERWIN OFFECIERS, MD, PHD

ANTWERP, BELGIUM

Because of the important function of the embryologic stapedia artery, it is taken for granted by many surgeons that the finding of such a persistent artery in postnatal humans during middle ear surgery should urge maximal caution in order not to damage the artery. Often, discontinuation of the surgery is recommended. Yet this attitude is based on theoretic considerations rather than on any clinical evidence of complications following injury to this vessel. The present paper describes the embryology in relation to this specific aspect and reviews the literature on the persistent stapedia artery, emphasizing the papers dealing with injury to this vessel. In addition, we report 4 cases of persistent stapedia artery from the files of almost 20,000 patients in whom tympanotomy was performed. From all these data we conclude that injury to this artery or even complete section probably does not cause major, if any, postoperative sequelae, and that consequently, middle ear surgery is not necessarily hindered by the presence of this vessel.

**KEY WORDS** — congenital hearing loss, facial nerve, middle ear, stapedia artery, stapes surgery.

### INTRODUCTION

Embryologically, the stapedia artery is a very important blood vessel. In humans the stem disappears at about 10 weeks of age, and the blood supply of the distal divisions is taken over by the external carotid artery.<sup>1</sup> However, a persistent stapedia artery is sometimes encountered during middle ear surgery or during postmortem examination. On the basis of its theoretic area of blood supply, injury to this artery is considered to be fairly hazardous, and many surgeons have advocated interrupting a surgical intervention when a persistent stapedia artery is found. But this policy is not supported by any clinical evidence. On the contrary, the few reports that mentioned injury or section of this artery did not observe any postoperative complications. The present paper reports on 4 more patients with a persistent stapedia artery, 2 of whom underwent elaborate middle ear surgery.

*Embryology.* The dorsal end of the second aortic arch, which originates from the internal carotid artery, constitutes the hyoid artery, a remnant of which is the caroticotympanic artery in adults.<sup>2</sup> The hyoid artery serves as the stem of the stapedia artery. A small posterior branch of the stapedia artery supplies the posterior tympanic cavity, the stapedia muscle, and the mastoid. The main stem of the stapedia artery splits into an upper and a lower branch. The anterior or supraorbital division of the upper branch gives rise to the supraorbital, frontal, anterior ethmoidal, and

lacrimar arteries. The posterior division of the upper branch gives rise to meningeal and temporal rami and to the arteria diploëtica magna. The lower (or maxillomandibular) division gives rise to the inferior alveolar and the infraorbital arteries.<sup>2-4</sup> At this stage, as at the adult stage in some primitive eutherians, the stapedia artery forms the primary blood supply to the nonneural tissues of the head.<sup>5</sup> The stapedia anlage at its earliest stage of development is a solid blastema lacking an obturator foramen.<sup>6</sup> In the 6-week-old embryo, this anlage folds around the stapedia artery, thus forming a dense mesenchymal ring with an obturator foramen.<sup>7</sup> At 9 weeks the stapes is cartilaginous.<sup>7</sup> Beyond a certain body size, the stapedia artery can no longer function as the sole supplier of its original territory, because the diameter of its stem is limited by the size of the intercrural foramen of the stapes.<sup>5</sup> Hence, the distal portion of the ventral pharyngeal artery — which is the precursor of the external carotid artery, directly arising from the aortic sac — joins with the maxillomandibular division of the stapedia artery. Subsequently, at 10 weeks of age, the stem of the stapedia artery atrophies and the anastomosis with the external carotid artery takes over the blood supply of both the upper and lower branches of the former stapedia artery.<sup>1,8</sup>

### PATIENTS AND METHODS

Two cases of persistent stapedia artery were re-

From the Department of Otolaryngology, University Hospital Nijmegen, Nijmegen, the Netherlands (Govaerts, Cremers), and the Department of Otolaryngology, St Augustinus Medical Institute, University of Antwerp, Antwerp, Belgium (Govaerts, Marquet, Offeciers).

REPRINTS — Paul J. Govaerts, MD, Dept of Otolaryngology, St Augustinus Medical Institute, University of Antwerp (UIA), B-2610 Antwerp, Wilrijk, Belgium.

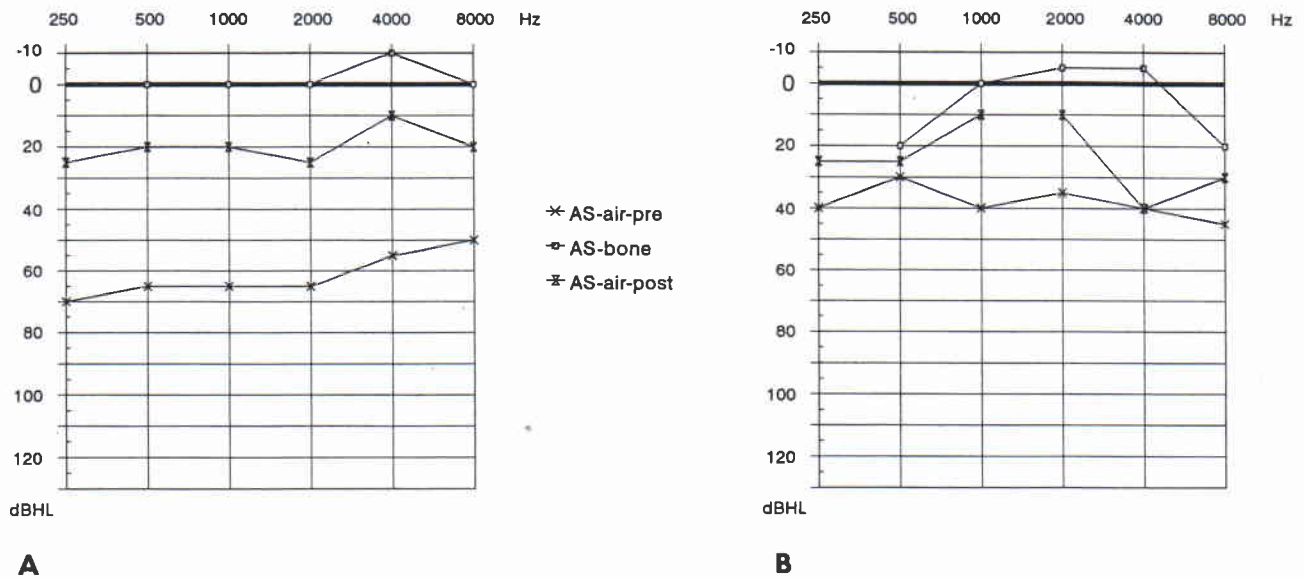


Fig 1. Audiograms of left ears (AS) showing preoperative and postoperative results. A) Case 2. B) Case 3.

trieved from the files of the University Hospital Nijmegen, and another 2 cases from the private files of one of the authors (F.E.O.) and of the late Prof Dr J. Marquet (St Augustinus Medical Institute, University of Antwerp). The files of the latter should have contained yet another case, as reported previously,<sup>9</sup> but the authors were not able to locate it. On the basis of the number of middle ear operations in the two groups, the prevalence of the anomaly can roughly be estimated at 2 in 7,500 and 3 in 12,000, respectively. This lies in the same range as the 1 in 5,000 to 1 in 10,000 prevalence reported by Schuknecht.<sup>10</sup> The first case belongs to the well-documented Nijmegen group of 144 ears with a congenital minor ear anomaly that underwent tympanotomy.<sup>11</sup> The second case from Nijmegen was encountered more recently and was therefore not included in this selected group of 144 cases. These data show that the prevalence of this anomaly in a selected group of congenital minor ear anomalies with conductive hearing loss is approximately 1 in 150.

## RESULTS

**Case 1.** A 4-year-old boy was referred to the otolaryngology department (Nijmegen) with a bilateral conductive hearing loss of 70 dB.<sup>12</sup> Exploratory tympanotomy of the left ear revealed several middle ear malformations. The chorda tympani was located too high in the epitympanum, the round window was situated in the center of the promontory, the facial nerve was not covered by bone, the long process of the incus was broad and connected to rudimentary stapedial crura, and there was no stapedial muscle or stapedial footplate. Surgery was discontinued. The right ear was operated on at the age of 14 years

(Nijmegen). The facial nerve was not covered by bone. The stapedial crura were rudimentary and a stapedial footplate was lacking. A pulsating artery was observed that ran from the round window between the rudimentary stapedial crura to enter the facial canal. The intervention was discontinued.

**Case 2.** A 14-year-old girl underwent exploratory tympanotomy on her left ear for alleged congenital conductive hearing loss (Nijmegen). The preoperative audiogram showed conductive hearing loss with a Fletcher index (mean of thresholds at 500, 1,000, and 2,000 Hz) of 65 dB (Fig 1A). Middle ear inspection revealed stapedial ankylosis. A persistent stapedial artery was found running through the obturator foramen of the stapes (Fig 2A). A calibrated hole was drilled posteriorly in the stapes footplate. Both crura of the stapes were fractured. During fracturing of the anterior stapedial crus with stapedial crural scissors, the artery was injured and profuse bleeding ensued. After the bleeding was stopped with Tabotamp (Johnson & Johnson), a Teflon-wire prosthesis was placed (Fig 2B) and the Tabotamp was removed. No postoperative complications occurred. The audiogram showed a Fletcher index of 20 dB (Fig 1A).

**Case 3.** An 8-year-old girl underwent middle ear surgery on her left ear for chronic otitis media with cholesteatoma (Antwerp). The preoperative audiogram showed conductive hearing loss with a Fletcher index of 35 dB (Fig 1B). Mastoidectomy, antroatticotomy, and posterior tympanotomy were performed. The long process of the incus and the posterior crus of the stapes had been destroyed. The incus was removed together with the entire cholesteatoma. A large stapedial artery was also present. Careful dissection of the cholesteatoma did not injure the artery.

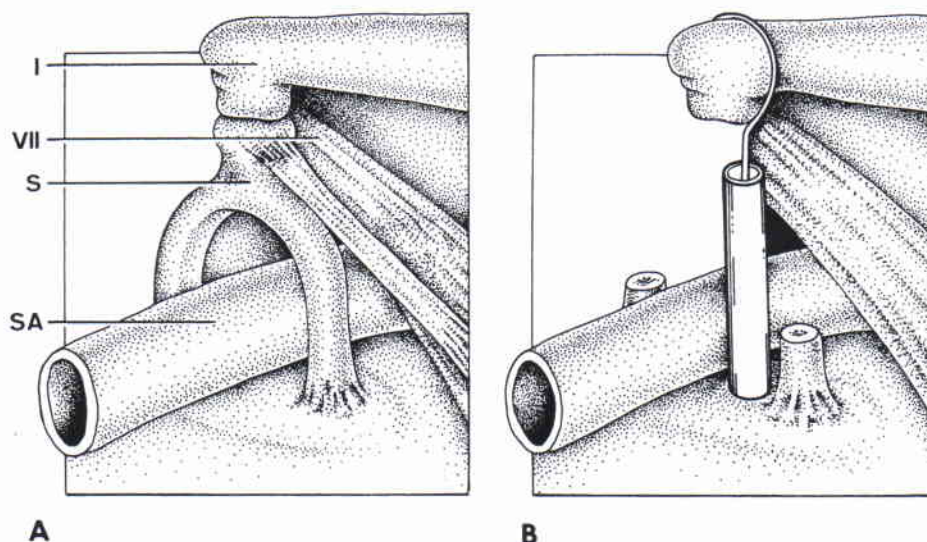


Fig 2. (Case 2) Schematic representation of perioperative findings. A) Persistent stapedial artery (SA). I — incus, VII — facial nerve, S — stapes. B) Teflon-wire prosthesis in calibrated hole in posterior part of footplate.

A monoblock tympano-ossicular allograft (tympanic membrane, malleus, and incus) was implanted.<sup>13</sup> No postoperative complications occurred. The audiogram showed a Fletcher index of 15 dB (Fig 1B). During a second-look operation 1 year later, the middle ear and mastoid were free of residual cholesteatoma.

**Case 4.** A 20-year-old woman underwent tympanotomy on her left ear and 2 years later on her right ear for mixed hearing loss with preoperative Fletcher indices of 65 dB (right ear) and 70 dB (left ear; Antwerp). A persistent stapedial artery was found on both sides. The right facial nerve was prolapsed against the stapes, and there was no stapedial muscle. Both stapes footplates showed ankylosis and were mobilized during an attempt to fracture the crura. In consequence the ears were closed. The postoperative Fletcher indices were 45 dB (right ear) and 70 dB (left ear).

#### DISCUSSION

The stapedial artery persists completely in quite a number of animals and partially in others. It is persistent in rodents, and in the guinea pig it passes between the crura of the stapes.<sup>14</sup> A persistent stapedial artery is rare in humans. The first report was published by Hyrtl<sup>15</sup> in 1836. House and Patterson<sup>16</sup> reviewed 17 reported cases in 1964. We were able to review 27 additional reported cases and add 4 cases from our own files,<sup>2,3,8,12,14,17-32</sup> making a total of 48 cases. Most of the data concern incidental findings during postmortem examination or during middle ear (mostly stapes) surgery. A prevalence of about 1 in 5,000 to 1 in 10,000 is estimated.<sup>10</sup> In merely 12 cases (including the present cases 2 and 3) this was an isolated finding, while the other cases showed multiple congenital anomalies (see Table<sup>2,8,14,16,18,19,23,24,27-29,32-37</sup>). Ten cases, including the present case 4, had documented

bilateral stapedial arteries. Twelve cases, including the present cases 2 and 4, showed stapedial footplate ankylosis. Eleven cases, including the present case 2, underwent stapedotomy, and in 9 cases, including the present case 2, a stapedial prosthesis was implanted. The artery was injured, clipped, or sectioned in 7 cases, including the present case 2.

The course of the persistent stapedial artery has already been described in detail in other papers.<sup>2,8</sup> The artery enters the middle ear cavity in the anterior inferior quadrant, then crosses the promontory just lateral to the round window membrane to course backward and upward, where it passes through the obturator foramen of the stapes, close to the anterior crus. It then immediately enters the horizontal portion of the facial canal through a bony dehiscence, usually located behind the cochleariform process. It leaves the facial canal, usually superiorly, dividing into an intracranial dural branch, substituting for the middle meningeal artery and a sphenoidal branch, anastomosing by a small branch to the orbital vessels. On the basis of the embryologic evolution of this vascular system, a persistent stapedial artery could hypothetically be of serious clinical importance by supplying part of the pyramidal tract in the region of the geniculate ganglion, as well as part of the medial lemniscus and of the trapezoid body. Hogg et al<sup>1</sup> warned of possible clinical implications of sectioning a persistent stapedial artery, such as transient or permanent crossed hemiplegia, tabes dorsalis-like symptoms, or hearing loss. Finding such a stapedial artery during middle ear surgery caused great concern for the surgeon to avoid injuring it and was often considered a reason to discontinue the operation. "A persistent stapedial artery should be treated with respect when found."<sup>38(p1241)</sup> Only 11 cases (including the present case 2) are described of stapedectomy



## REVIEW OF LITERATURE ON PERSISTENT STAPEDIAL ARTERY

Authors	PSA in 1 or 2 Ears	Footplate Ankylosis	Stapes Surgery	Stapes Prosthesis	Postop AB Gap	Injury to PSA
Postmortem examination, other congenital anomalies present						
Altmann <sup>33</sup>	2	NA	-	-	NR	NR
Kelemen <sup>34</sup>	2	NA	-	-	NR	NR
Sando et al <sup>19</sup>	2	NA	-	-	NR	NR
Egami et al <sup>23</sup>	2	NA	-	-	NR	NR
Harada and Sando <sup>27</sup>	2	NA	-	-	NR	NR
	2	NA	-	-	NR	NR
	2	NA	-	-	NR	NR
In vivo examination, other congenital anomalies present						
De Pinnies and Ongsiaka <sup>37</sup>	1*	-	-	-	NR	Bleeding
Maran <sup>14</sup>	1	+	+	+	80	-
Marion et al <sup>8</sup>	2	NA	-	-	NR	NR
Our case 1	1	-	-	-	60	-
Our case 4	2	+	-	-	45-70	-
In vivo examination, no other congenital anomalies						
Hough <sup>35</sup>	2	+	+	-	Excellent	Bleeding
Baron <sup>36</sup>	1*	+	+	+	0	-
House and Patterson <sup>16</sup>	1*	+	+	+	Closure	-
	1*	+	+	+	Closure	-
Steffen <sup>2</sup>	1	+	+	NA	NA	NA
Gerhardt and Otto <sup>18</sup>	1*	+	+	+	5	Cut
Schweitzer and Lilly <sup>28</sup>	1*	+	+	+	0	Cut
Fisch et al <sup>24</sup>	1*	-	-	-	NR	Clip
Yamamoto and Hirono <sup>29</sup>	1	+	+	+	5	Cut
Pahor and Hussain <sup>32</sup>	1	+	+	+	5	-
Our case 2	1*	+	+	+	20	Bleeding
Our case 3	1*	-	-	-	15	-

PSA — persistent stapedial artery, AB — air-bone, NA — not available, NR — not relevant.

\*No information available on second ear.

in an ear with a persistent stapedial artery, and only 1 patient had elaborate middle ear surgery for cholesteatoma (the present case 3). As shown in the Table, functional results are very good and comparable to ordinary stapedotomy results if the persistent stapedial artery is an isolated anomaly. On the contrary, in cases of associated congenital abnormalities (see Table), the functional results appear to be rather poor. The mere presence of the artery, however, does not seem to impair the functional results. Three authors mentioned having injured this artery, and 4 mentioned having cut or clipped the vessel without any postoperative complications (see Table). To our knowledge no cases of damage to the artery have led to unfavorable results. It is possible to cautiously

interpret these data to mean that a persistent stapedial artery in the postnatal human no longer forms the main blood supply to any important structure in the head. Probably, sufficient collaterals exist to provide an alternative blood supply.

In conclusion, the finding of a persistent stapedial artery during middle ear surgery should not impede the intervention. Stapes surgery may be equally as successful as it would have been without this vessel. Injury to this artery is not likely to have any consequences but bleeding, which can adequately be dealt with. The present paper gives evidence that successful middle ear surgery, both functionally and anatomically, is highly practicable.

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