

The history of eustachian tube catheterization

Abstract

The aim of this paper is to present the thesis that the necessity of Eustachian tube catheterization can be rationalized irrespective of time, through a text summary of knowledges and discoveries by senior doctors for a long time. Focusing on concept development related to Eustachian tube catheterization from 1724 to 1861, its process can be subdivided into seven sub-themes: 1) Beginning of Eustachian tube catheterization for therapeutic reasons. 2) Evaluation of the patency of the Eustachian tube. 3) Normal state of the Eustachian tube as a prerequisite for normal hearing. 4) Therapeutic test of inflation of the Eustachian tube. 5) Eustachian tube catheterization for diagnostic reasons. 6) Eustachian tube catheterization as a first step before artificial perforation of tympanic membrane. 7) Toynbee diagnostic tube used with the Eustachian tube catheter. It is the time to revive the spirit and achievements of these trailblazers in the field of Eustachian tube catheterization, and moreover, to recognize the proposition that 'ideally normal middle ear cavity pressure with perfectly equal balance between both ears' is the core prerequisite before diagnosis and treatment for any symptom and disease as well as hearing loss. This concept should be also with the starting point of opening up the coming 'Digital Health Age'.

Keywords: history, otology, eustachian tube catheterization, eustachian tube obstruction, digital health

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Hee-Young Kim

Otorhinolaryngology, Kim ENT clinic, Republic of Korea

Correspondence: Hee-Young Kim, Otorhinolaryngology, Kim ENT Clinic, 2nd fl. 119, Jangseungbaegi-ro, Dongjak-gu, Seoul, 06935, Republic of Korea, Tel +82-02-855-7541, Email kheeyoung@gmail.com

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Introduction

It is rather conservative to say that the history of otology is in line with the history of concept development related to Eustachian tube catheterization. Based on the historical book 'The history of otology' in 2015,¹ the literature materials from 1724 to 1861, which are related to catheterization of the Eustachian tube, are selected and arranged in this article. There can be some differences between the both in terms of interpretation of the historical significance about them.

In 1724, Eustachian tube catheterization was first described by Edmé Gilles Guyot (?). And after about 125 years passed since then, Joseph Toynbee (1815-1866) invented an 'auscultation tube', which he called 'otoscope', in 1850. At present, according to Code of Federal Regulations Title 21 which was revised as of April 1, 2015 by U.S. Food and Drug Administration, the 'auscultation tube' is labeled as 'Sec. 874.1925 Toynbee diagnostic tube', and it is identified as follows: 'The Toynbee diagnostic tube is a listening device intended to determine the degree of openness of the Eustachian tube.' Eustachian tube catheter can be found in 'Sec. 874.4175 Nasopharyngeal catheter', which is identified as follows: 'A nasopharyngeal catheter is a device consisting of a bougie of filiform catheter that is intended for use in probing or dilating the Eustachian tube. This generic type of device includes Eustachian catheters.'

In recent years, although Eustachian tube catheter itself was almost forgotten by most otolaryngologists, their valuable opinions of some excellent researchers regardless of time, seem to be sufficient to rationalize also the necessity of Eustachian tube catheterization irrespective of time.

Discussion

Beginning of Eustachian tube catheterization for therapeutic reasons (1724)

Catheterization of the Eustachian tube was the first surgical step forward taken in otology in the 18th century. The procedure was first

described by Edmé Gilles Guyot, postmaster of Versailles, in 1724. Seeking relief from his hearing difficulty he had consulted physicians in vain. Saissy mentioned that the French surgeon Raphaël-Bienvenu Sabatier (1732-1811)² reported that Guyot's symptoms stimulated him to discover a way of injecting into the Eustachian tube.³ He presented his method to the Royal Academy of Sciences in Paris: "Anatomists do not believe that the tube of Eustachio can be injected via the mouth; however Mr. Guyot, postmaster in Versailles, has found an instrument for doing this that the Academy has considered to be very ingenious. The main part of it is a curved tube, which is inserted at the back of the mouth, behind and above the palate, so it can be in contact with the Eustachian tube into which the injection will be made. At least the entrance to the tube can be washed, which can be useful in certain cases".⁴

The British army surgeon Archibald Cleland (1700-1771) recommended introducing a catheter through the nose. In 1741, Cleland published his procedure without mentioning Guyot, with whom he probably had no association⁵ (Figure 1).

The catheterization through the nose method soon became the main one. Although most physicians rejected catheterization through the mouth as being impracticable, in the beginning some others tried to develop Guyot's method, in particular van Swieten, and the Dutch physician Gerhard Gisbert ten Haaff (1720-1791), who wrote a short report concerning the healing of deafness, rustling and ringing in the ears by injection into the Eustachian tubes.⁶

Just as Cleland failed to take Guyot into consideration, the Frenchman Antoine Petit, in 1753, and the Englishman Jonathan Wathen, in 1755, claimed for themselves the discovery of catheterization through the nose, without mentioning Cleland. Wathen gave credit to his teacher the English surgeon John Douglas in 1759 who, in his anatomical lectures, demonstrated the possibility of catheterization through the nose^{7,8} (Figure 2).

Many other famous physicians considered catheterization to be either impracticable or unsafe in its application, such as the English

surgeon Benjamin Bell (1749-1806) and Portal. Such negative judgments of otherwise first rate authors did not appear so strange, considering that catheterization of the Eustachian tube could be done only by the most dexterous practitioners, because of the imperfect instrumentation available at the end of the 18th century. A scientific basis was needed to support the view that the Eustachian tube constituted the main gateway to the middle ear for therapeutic agents.

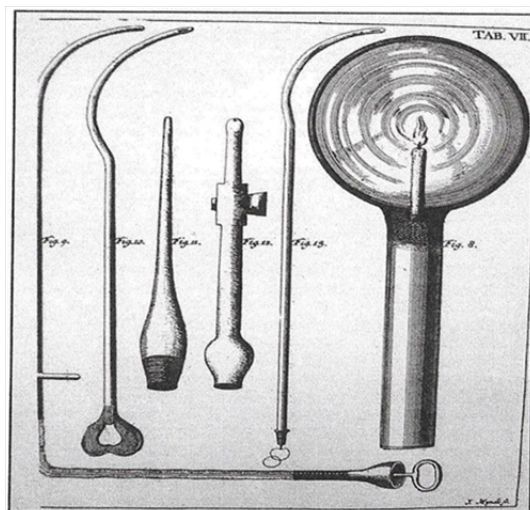


Figure 1 Cleland's ear instruments.

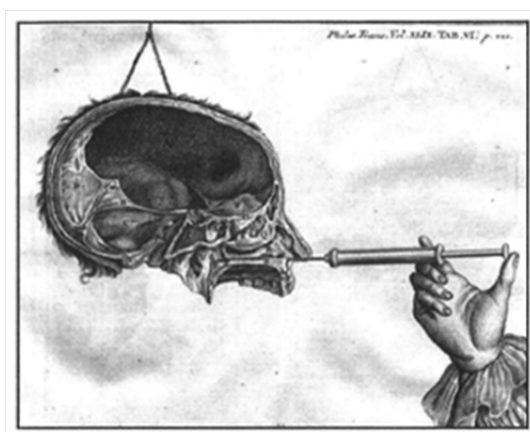


Figure 2 Warthen's catheterization of the Eustachian tube.

In 1788, an unknown author⁹ proposed that by making the patient hold his breath, and when ready, it facilitated the insertion of the silver catheter, and enlarged the Eustachian tube opening.¹⁰ However, lacking anatomical knowledge and being intimidated by patients' aversion, most physicians preferred to continue to use therapeutic measures based simply on crude empirical considerations, with no rational anatomical and physiological foundation. As a result, other more difficult and dangerous operations, such as the trepanation of the mastoid process or artificial perforation of the tympanic membrane, were used for the same indication, many years after catheterization had been clearly described.

Evaluation of the patency of the eustachian tube (1825)

Around 1825, Laennec was the first to listen with a stethoscope to the mastoid area to evaluate the permeability of the Eustachian tube during a Valsalva maneuver.¹¹

To evaluate the permeability of the Eustachian tube, Saissy examined a patient as follows: "First closing his mouth and nose, and then making a strong expiration, he perceived the air to pass into the internal ear, and to strike upon the membrana tympani (tympanic membrane). He experienced the same sensation when he blew the nose. I injected the tubes and the liquor penetrated to the mastoid cells. These experiments clearly proved that the Eustachian tube was free".¹²

The quality of the breath of air was related in particular to the presence of mucosity inside the Eustachian tube or the tympanic cavity. The main difficulty with this technique was to interpret the various noises heard and their correlation with specific Eustachian tube problem. Deleau tried to develop this technique combining it with an air douche through Eustachian catheter without much success.¹³

Antoine Saissy (1756-1822) recommended the following operation to remove strictures: the introduction of a catheter, fitted with a stylet, as far as the stricture and when it was reached, "the stylet is to be gently pushed forward till the cessation of resistance".¹⁴

Wilhelm Kramer (1801-1875) was against fluid injections, which were better replaced by Deleau's air douche. The physician brought his own ear close to that of the patient, and was able to hear the "noise which the condensed air makes in rushing into the ear of the patient", when the Eustachian tube was open. When no noise was heard, Kramer introduced a "catgut bougie", with which he tried to push up the tympanic membrane".¹⁵

Nicolas Deleau the Younger (1799-1862) from 1826 to 1830, was devoted to different aspects of the catheterization of the Eustachian tube, and the use of the "douche d'air air shower - air douche", first used therapeutically then for diagnosis. The third stage, from 1830 to 1836, was spent on the function and effect of atmospheric air in the middle ear.¹⁶

Deleau then concentrated his work almost exclusively on diseases of the middle ear with special emphasis on perfecting the catheterization of the Eustachian tube. In the second part of the 1820's, he replaced the rigid metallic catheter with a flexible elastic one. He then showed that injections of liquid through the catheter, as recommended by Saissy and Itard,¹⁷ not only failed to render hearing, but were also the cause of irreparable lesions. He substituted atmospheric air for the liquid and reintroduced the air douche. It was not a new idea as Cleland and others had already mentioned it. Deleau used an India-rubber ball or an air pump to blow air into the catheter.¹⁸ If there were nasal discharge and the foreign objects in the postnasal area, they could enter the tympanic cavity with air sucked into the middle ear through the Eustachian tube while using the air douche, which he substituted atmospheric air for the liquid and reintroduced. It may be asked how he removed nasal discharge and the foreign body around the opening of the Eustachian tube perfectly at that time. Today, of course, such this pre-operative care must be accomplished without fail by the operator before the catheterization of the Eustachian tube.

He limited the use of injections to cases involving the removal of foreign objects if the tympanic membrane was defective. He published many successful case histories of patients treated with the air douche between 1827 and 1828.¹⁹ This technique remained one of his most useful ones for treating deaf-mutes.²⁰ He emphasized, however, that the process of forcing air into the middle ear in itself expanded the Eustachian tube. This technique was successful only in cases of swelling and not those of connected tissue stricture.

Inspired by Laennec's investigations into the auscultation of

the mastoid process,¹¹ Deleau explored the clinical significance of auscultation of the ear during insufflations of air through the Eustachian tube.¹³ His auscultation technique was still limited to putting his ear close to that of the patient. If the tympanic cavity contained the normal amount of air, and the Eustachian tube was open, a noise was heard that could be compared to “quite heavy rain which was heard falling on the leaves of a tree”, that Deleau called the “dry noise of the box (i.e. tympanic cavity)”. In this situation, the injection of air was painless, and accompanied only by a “smooth numbness” in the ear without the level of hearing being changed.²¹ Frequently, this noise was accompanied by a whirring sound produced by the vibrations of the entrance to the Eustachian tube. This second noise, called “noise of a horn”, could be heard by approaching the examiner’s ear to the nostrils or by asking the patient to open his mouth.²² If there were strictures in the Eustachian tube, the noise heard was like that in a normal ear but, after the catheter was removed, the patient’s hearing improved for at least a few hours. If there were secretions in the tympanic cavity, a gurgling sound was heard which Deleau called “mucous noise”.²³

The important thing to remember is that the method only tests patency of the Eustachian tube and does not reflect on its function.²⁴

Recognition of normal state of the eustachian tube as a prerequisite for normal hearing (1836)

In 1836, Deleau did other studies on atmospheric air in the middle ear and the effects of its modification on hearing.²⁵ It was recognized that a patient’s Eustachian tube was a prerequisite for normal hearing. Based on this, Deleau reasoned that hearing difficulties associated with catarrhal obstruction of the Eustachian tube were caused by a change in the tension of the tympanic membrane, which in turn was due to resorption of the air within the tympanic cavity. This theory is still accepted at present 21th century. Pressure differences between the middle ear and the atmosphere cause temporary conductive hearing loss by decreased motion of the tympanic membrane and ossicles of the ear.²⁶ This point includes clue for explaining the mechanism of tinnitus due to Eustachian tube obstruction. Improvement of tinnitus after Eustachian tube catheterization can mean that the tinnitus is from the hypersensitivity of cochlear nucleus following decrease of afferent nerve stimuli owing to air-bone gap.^{24,27,28} In addition, this prerequisite should be considered without fail before prescribing the hearing aids for the patients.

Therapeutic test of inflation of the eustachian tube (1836)

“To obtain any degree of certainty”, it was necessary to catheterize the Eustachian tube with an air douche: an audible gurgling, an agreeable sensation of relief, a lessening of tinnitus, and an improvement of hearing were clear diagnostic signs.²⁹ The term of ‘therapeutic test’ is defined as “a test to aid in diagnosis of an undiagnosed disease by giving the specific remedy for the disease suspected.” The clear diagnostic sign that the symptoms of the patients are removed after the catheterization of the Eustachian tube, is sufficient to explain the definition of ‘therapeutic test’.

Seeing that there was a perforation of the tympanic membrane, Deleau pushed out the foreign body with an air douche through the Eustachian tube and successfully treated the acute inflammation of the tympanic cavity.³⁰

Deleau considered nervous deafness to be incurable. Free admission of air into the tympanic cavity was the characteristic symptom of this

diagnosis. It was later shown that this sign was not pathognomonic because it was also present in ankylosis of the stapes. Especially in such ‘ankylosis of the ossicles’, they also can return to the normal condition by the physical force of blowing air. This process can cause serious damage with pain, ear fullness, and dizziness to the operator’s tympanic membrane through Toynbee diagnostic tube in such a case using the device.

In the same publication, Deleau described at least one patient who had the three symptoms - dizziness, tinnitus, and hearing impairment of what was later known as Menière’s disease. He improved the situation by catheterization of the Eustachian tube together with an air douche^{31,32} (Figures 3 & 4). This case is an typical example explaining the reason why Eustachian tube obstruction should be ruled out first, before suspecting Menière’s disease.^{24,27,33} Eustachian tube obstruction as one of the principal causes of ‘hearing loss,’²⁷ and/or ‘ear fullness’²⁷, and/or ‘tinnitus’,²⁷ and/or ‘headache (sinus headache, including otalgia),’³⁴ and/or ‘vertigo’,^{27,33,35} has already been recognized by for a long time.^{27,33,35} They should be subjected to the therapeutic test of inflation of the tubes as a first step in a thorough clinical investigation.^{27,33} Practical otology is nevertheless indebted to him for significant improvements in the technique of catheterization of the Eustachian tube and for the introduction of the air douche through the catheter.

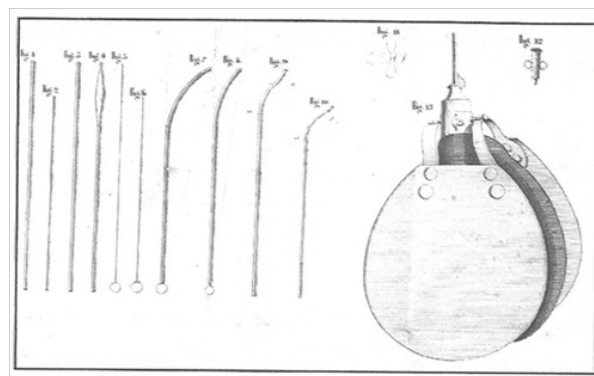


Figure 3 Deleau's Eustachian tube catheters.

Eustachian tube catheterization for diagnostic reasons (1838)

Invented in the first part of the 18th century, and later largely used for therapeutic reasons, the catheterization of the Eustachian tube seems to have been introduced by for diagnostic reasons in 1838.³⁶

In 1838, Deleau tried to classify the different noises heard as: “rain”, “more or less mucous ... wing” from the entrance of the Eustachian tube, “tube noise”, “box noise more or less mucous” originating from the tympanic cavity, and “noise of the tympanic membrane; they are called shrapnel and whistling. These noises are high or low”.³⁷

Carl Gustav Lincke (1804-1849) vividly described the subjective and objective symptoms of stricture of the Eustachian tube. For example, the sound that occurred during an air douche if the stricture was associated with chronic “blennorrhoea of the Eustachian tube and tympanic cavity”, was the kind heard when “a small stick or spoon is inserted in stiff-boiled starch and retracted rather quickly”.³⁸

In 1841, Curtis invented the “cephaloscope” to discern normal and abnormal sounds in the organ of hearing related to the permeability or impermeability of the Eustachian tube³⁹ (Figure 5).

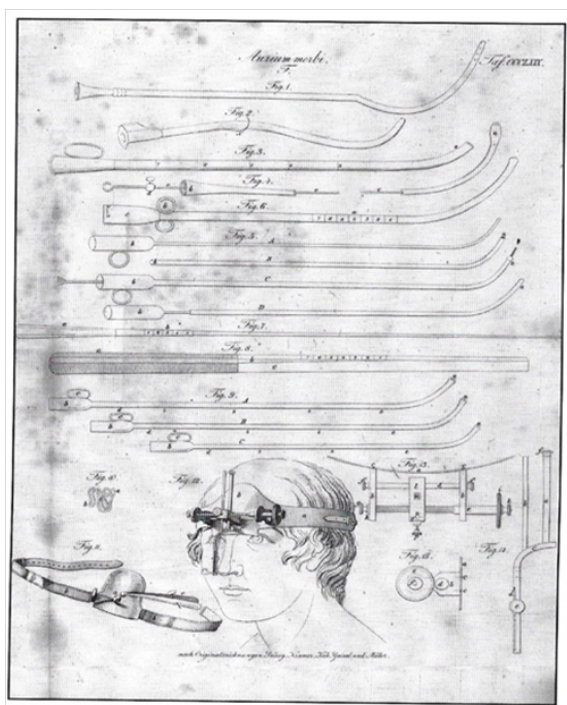


Figure 4 Froriep's assortment of Eustachian tube catheters.

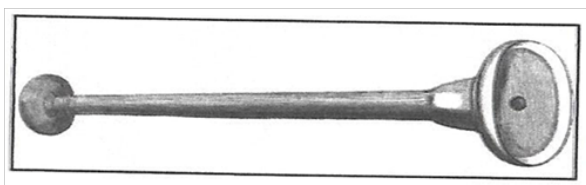


Figure 5 Curtis' cephaloscope.

Eustachian tube catheterization as a first step before artificial perforation of tympanic membrane (1843)

In 1843, Marcellin Emile Hubert-Valleroux (1812-1884) He tried to answer three questions about artificial perforation of the tympanic membrane: 1) does perforation of the tympanic membrane have any effect on hearing; 2) Is artificial perforation of the tympanic membrane free from danger; 3) Can we replace this operation by another method such as catheterization of the Eustachian tube.⁴⁰ He remarked first that each perforation of the tympanic membrane had an effect on hearing. Secondly, many serious accidents had followed the operation. After reviewing the usual indications of the operation, he concluded that artificial perforation of the tympanic membrane should be done only in cases of an "incurable obstruction of both Eustachian tubes when the rest of the organ of hearing is normal".⁴¹ In fact, even today, it can very often happen that ventilation tube insertion of tympanic membrane without consideration of the state of Eustachian tube is performed. It should be counted that the patient's Eustachian tubes were abandoned perfectly by their otolaryngologists. Because the method of Eustachian tube catheterization still exists on this earth.

In 1847, James Yearsley (1805-1869) which went through six editions.⁴² Catheterization of the Eustachian tube was a valuable "diagnostic and remedial method", which led Yearsley to write its history.⁴³ Eustachian tube catheterization may be of both diagnostic and therapeutic value.^{24,27,33,34}

Toynbee diagnostic tube used with eustachian tube catheter (1850)

The word otoscope was introduced in 1850 by the Englishman Joseph Toynbee (1815-1866) to refer to an instrument used for auscultation of the sound made during insufflations of air into the Eustachian tube⁴⁴ (Figure 6). In 1862, the English army physician John Brunton (1836-1899) used this word again for the instrument which was definitively accepted as the otoscope.⁴⁵ The last step in the development of the otoscope was to insert a magnification system, which was also done by Brunton.

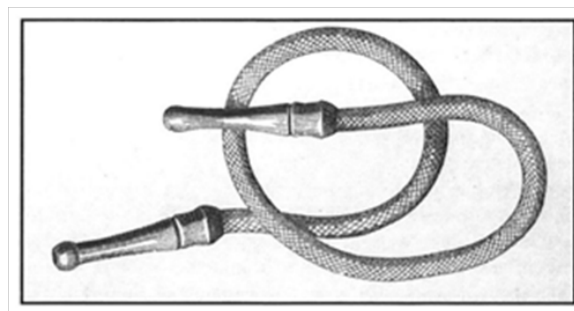


Figure 6 Toynbee's otoscope.

It was used during insufflations of air through the Eustachian tube with a catheter. In 1861, Kramer slightly modified Toynbee's technique.⁴⁶

Conclusion

During this period from 1724 to 1861, the standard of instrument, technique and concept for Eustachian tube catheterization is still in its infancy. However, the progress of concept development is, in itself, the procedure of approaching these patients for treatment at the coalface even today. It is the very precious historical asset which should be preserved forever for good.

After Eustachian tube catheterization was first described by Edmé Gilles Guyot in 1724, until it was recognized that a patient's Eustachian tube was a prerequisite for normal hearing through the study by Nicolas Deleau the Younger (1799-1862) in 1836, about 110years flowed on. Today after about 165years passed since then, it is the time to revive the spirit and achievements of these trailblazers in the field of Eustachian tube catheterization, and moreover, to recognize the proposition that 'ideally normal middle ear cavity pressure with perfectly equal balance between both ears' is the core prerequisite before diagnosis and treatment for any symptom and disease as well as hearing loss.^{24,27,33,34} Eustachian tube catheterization may be of both diagnostic and therapeutic value; these patients of Eustachian tube obstruction should be subjected to the therapeutic test of inflation of the tubes as a first step in a thorough clinical investigation.^{27,33} This should be also with the starting point of opening up the coming 'Digital Health Age'.

In recent years, although this Eustachian tube catheter itself was almost forgotten by most otolaryngologists, their valuable opinions of some excellent researchers seem to be sufficient to rationalize the necessity of this procedure.²⁴ Some researchers mention that blocked Eustachian tubes can cause several symptoms, including ears that hurt and feel full, ringing or popping noises, hearing problems, feeling a little dizzy.⁴⁷ Especially in cases complaining of nausea, and/or vomiting, and/or perspiration accompanied concomitantly by vertigo, which are attributable to Eustachian tube obstruction, it also seems

distinct that Laryngopharyngeal reflux or Gastroesophageal reflux disease has a reciprocal causal relationship with Eustachian tube obstruction, which cause a vicious cycle.³³

Eustachian tube catheterization is also the most fundamental and essential technique for a veritable otolaryngologist.²⁷ The history of Eustachian tube catheterization is ongoing.

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Conflicts of interest

Author declares there are no conflicts of interest.

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