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OTOLOGY

An alternative model for stapedectomy training in residency program: sheep cadaver ear

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Abstract To determine the usefulness of sheep cadaver ear as a complementary model for training of stapedectomy at residency programs, 2 of our 4 year residents were included in the study and each operated 20 sheep ears. All routine steps of stapedectomy operation were performed, and their success and complication scores were recorded. Performance of residents for stapedectomy and teflon piston placement in sheep ears were evaluated by the authors. Success of both residents improved progressively. Success and complications were impressively better in the second 10 ears than the initial 10 for each resident. Both residents had better outcomes in last 10 ears. Sheep cadaver ear is an excellent model for stapedectomy training in residency and helps to improve surgical skills. We offer sheep cadaver ear training model especially in the countries where obtaining human cadaver temporal bone is difficult.

Keywords Stapedectomy · Residency · Learning curve · Sheep ear · Animal model

Introduction

The number of stapedectomy operations has gradually decreased over the past 20 years. It is considered that fewer patients are requiring stapedectomy operations compared to 2 decades before. This can be attributed to several reasons. Better fluoridation of water supplies [14], and immunization programmes against measles are proposed to be the preventive measures that result in decrease of otosclerosis incidence [10]. Improved quality of hearing aids may be the reason for these patients to reject operation [15]. Additionally, the number of otology centres along with otologists is steadily increasing and consequently the number of stapedectomy cases per each surgeon has dramatically decreased.

In 1979 Schuknecht reported the decreasing caseload of stapes surgery in residency training programs that affected training adversely, and offered a subspecialty of otology after a 2-year core program in otolaryngology [12]. Bellucci also commented on declining number of cases, and stated that it might be impossible for the practicing otologist to maintain sufficient expertise for the performance of an occasional stapedectomy [2]. There are debates in literature whether stapedectomy should be taught to residents. Many centres reported their concern that hearing results in resident-performed stapedectomies were significantly worse than that of experienced otologic surgeons [1, 3, 6, 16].

The operation room should not be considered as the ideal place to learn stapedectomy with respect to ethical issues and practice. Levenson proposed a teaching module for stapes surgery and pointed that residents who attended this module got superior success at their stapedectomy results compared to non-attenders [8]. Standard method for teaching stapedectomy is human temporal bone studies.

Temporal bone study has great benefits in both initial and advanced steps of learning curve in stapes surgery. However, limited amount of temporal bone laboratories and difficulties of obtaining human cadaver and relevant costs are major handicaps.

Animal models have been used for many years for the improvement of surgical skills and experience. Morpholog-

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ical similarities between the structures of animal model and human ear define the value of the model for otologic training. Lavinsky described the sheep ear as a model for surgical training. He performed utriculostomy in sheep ear and demonstrated that middle ear of the sheep had significant anatomical and histological similarities to the human ear [7]. Seibel et al. recently carried on a morphometric study of external and middle ear anatomy of sheep [13]. Significant similarities were observed between sheep and human middle ear structures and they suggested that sheep ear might be an useful model for some middle ear procedures (Figs. 1, 2).

In this study we investigated the place of sheep ear model in the training of residents for stapedectomy operations. Two of our 4 year (senior) residents supervised by the authors applied stapedectomy procedure to 20 sheep ears. They had done about 30 different tympanoplasty procedures on patients before and had been already familiar with middle ear structures. They had also taken place as assistant surgeons in many stapedectomy operations.

Fig. 1 Transcanal view of sheep middle ear and ossicles

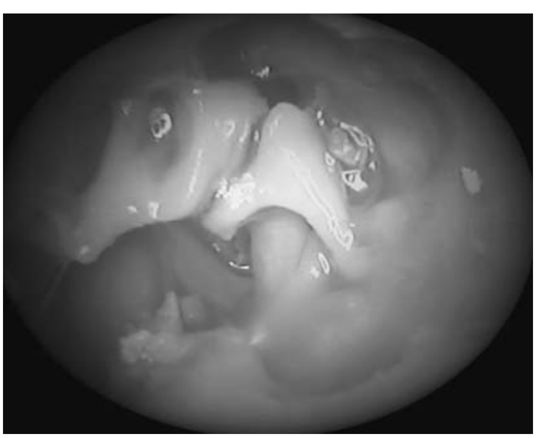

Fig. 2 Transcanal view of sheep middle ear after fracturing stapedial cruras

Methods

Prior to training, theoretical information about stapedectomy and surgical steps was discussed. Fresh sheep heads were obtained from the market same day and prepared for the procedure. The heads were fixed in special trays and surgical microscope was used. Our standard approach is via transcanal route and includes elevation of tympanomeatal flep and exposure of middle ear structures and ossicles. Separation of incudostapedial joint and cutting stapedial tendon is followed by removal of stapedial cruras and fenestration of footplate. Then, the teflon piston is hooked to incus and is placed to a small fenestra. All these steps were observed by the authors and any complications were recorded. After each case, possible causes for complications were discussed. No more than 4 ears were allowed to be done at each time and total number was 20 ears per resident. The training period was divided into two steps: first 10 and the second 10 ears for each resident. Two training periods were compared in terms of success and complication scores. Following parameters were determined: (1) site of the ear (right versus left), (2) duration of procedure, (3) tympanomeatal flap integrity (teared versus intact), (4) complications while cutting stapedial tendon and incudostapedial joint separation (successful versus incus dislocation), (5) complications of stapedial crura fracturing (no complication, en-block fracture with footplate), (6) complications of small fenestration (successful small fenestra versus partial/total fracture of footplate or crack in displacement of footplate), (7) placement of teflon piston (successful versus unsuccessful). Graphs were plotted in Microsoft Excel 2000, χ^2, Kruskall–Wallis, Mann–Whitney *U* and Pearson's correlation analysis carried out with SPSS for Windows Version 13.0 (SPSS inc, Chicago). A *P* value of 0.05 was considered significant.

Results

Each of the 2 fourth year residents performed stapedectomy in 20 sheep ears (R1, R2). For all parameters, both residents had similar outcomes therefore first and last 10 cases of R1 and R2 were analysed together as the first and last 20 ears. In the analysis of all steps; there was no statistical difference between left and right ears ($P > 0.05$). Therefore both sites were evaluated together. Mean duration of procedures from the beginning of tympanomeatal flep preparation to teflon piston insertion was 20.75 min for all ears. Mean length for the first 20 ears was 25.20 min and 16.80 for the second 20 ears ($P < 0.05$) (Fig. 3). Tears in tympanomeatal flap were encountered in 1 ear of R1 and R2 (5%). Both tears occurred in first 10 cases. No complication was seen during stapedial tendon cutting. R1 dislocated incus in 3 cases (15%) during

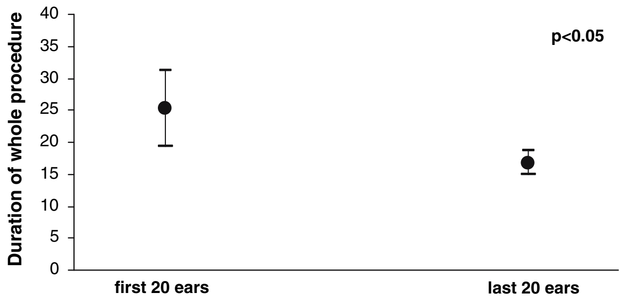

Fig. 3 Overall length of procedure from tympanomeatal flep elevation to teflon piston placement in first and second 20 ears

incudostapedial separation, whereas R2 dislocated incus in 1 case (5%). In removal of stapedial cruras both residents were not successful in 4 ears (20%) because of footplate dislocation, and all of them occurred during the first 20 ears. Making the small fenestra was the most challenging step for both residents. Both residents successfully performed a small fenestra in only half of the cases. Similarly both were able to make a small fenestra in only 3 of the first 20 cases. In the next 20 ears their success was remarkably increased. R1 fully penetrated the last 7 footplate without any complication. R2 had only 1 complication in last 8 footplates. In comparing the success rates of footplate fenestration, between the first and last 20 ears, success increased significantly in last group (Fig. 4). R1 fully managed small fenestra technique, without complication in last 5 ears (100%). R2 had a success rate of (80%) in last 5 ears. This step was the most important goal of our study to achieve familiarity with footplate manipulations. R1 was successful in placing teflon piston in 16 ears (80%), whereas R2 inserted piston in 17 cases (85%). Teflon piston placement was trained in all ears unless incus dislocation occurred.

Discussion

Stapedectomy with a prosthesis placement has been a standard therapeutic approach in otosclerotic patients with

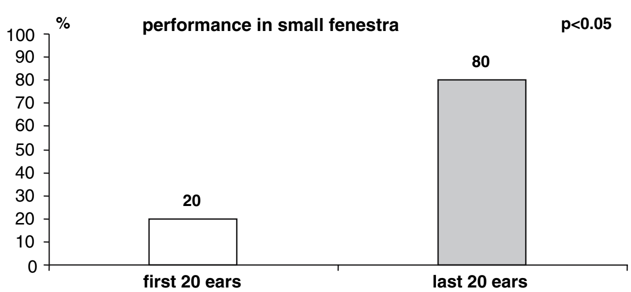

Fig. 4 Overall success of residents in performing small fenestra at first and second 20 ears

hearing loss. It is a successful operation in terms of hearing gain if a very delicate technique, based on a great expertise, is applied. However, the 'boon' years of stapedectomy are in the past due to the decline of number of operations per otologist and residents in training. New and carefully designed approaches to stapedectomy training that maximize the resident's experience are needed. There are many reports from residency programs that resident performed stapedectomies yield less favourable results than that of attendings [1, 3, 6, 16]. As in any surgical procedure, success rate increases with experience and every surgeon has a learning curve. Yung et al. [17] evaluated learning curve for stapes surgery. They pointed out that success increased with surgical experience and complications were higher at the earlier stages of learning curve. Stapedectomy is conceptually simple but technically difficult. Early exposure to stapes surgery and temporal bone dissection are essential to learning [9]. Levenson [8] evaluated learning pathways of stapedectomy and moving from the point "operation room cannot be considered as the ideal place to learn stapedectomy," he proposed a teaching model for stapedectomy. In his study, residents who attended to training program showed better performance compared to non-attenders. He used fresh human temporal bones as a model. There is no doubt for benefits of studying with human temporal bones. But residents have limited access to a fully equipped temporal bone laboratory in many countries. The cost of temporal bone training per resident was reported to be $1.520 by Levenson. Farrier clearly recognized that "the most critical steps of stapes surgery were footplate perforation and placement of the prosthesis." He recommended a model using superglue gel (cyanoacrilate), which would allow for repetitive perforation of the oval window by forming a new window with superglue after each procedure [4]. But this newly formed window with superglue cannot simulate natural tensions of oval window.

An animal model identical to human ear can be a valuable model for otologic training. Ethical concepts and costs in obtaining human temporal bone make it an un-practical model. Oelsner et al. used a rabbit ear model for training microsurgical reanastomosis of the fallopian canal in rabbits [11]. Result of his project strongly demonstrated the benefits of a microsurgical laboratory training program. Goksu et al. investigated temporal bone anatomy of guinea pigs [5]. He pointed that temporal bone of the guinea pigs was a good model for the human ear. However both rabbit and guinea pigs have smaller dimensions compared to sheep ear, as well as less similarity to human ear than sheep ear. Size of sheep ear structures is about two third of humans' which allows easier manipulation [13]. Obtaining both rabbit and guinea pig temporal bones are more difficult with respect to cost and ethical issues. In sheep ear structure of ossicles, and relationship of facial nerve and ossicles

Table 1 Comparison of local cost, ethical aspect, size similarity and obtainment of human, sheep, guinea pig and rabbit temporal bones

	Estimated cost	Ethical drawback	Size	Obtainment
Temporal bone	$76	Most prominent	Original	Difficult
Sheep ear	$2	No ethical issue	Two third of human	Very easy
Rabbit ear	$20	Prominent	Much smaller	Difficult
Guinea pig	$30	Prominent	Much smaller	Difficult

is very similar to humans (Table 1). Visiospatial orientation for middle ear structures especially for footplate can only be acquired by manipulation. Feeling of footplate tension must be experienced before the operation room experience. Fenestrating the footplate cannot be taught, but it must learned. Experience in manipulating footplate in sheep ear is the most valuable step for gaining surgical skill. Working on a mobile footplate is more challenging and needs more delicate manipulation. At the beginning of our study the residents had more complications during fenestration but later with increasing familiarity to footplate tension their success for making small fenestra increased impressively. Compared to temporal bone laboratory, and other animal models, cost for sheep ear is neglectable and is easily obtained without any ethical drawback. It can be obtained from the market with very low costs. In many countries obtaining human body cadavers is very difficult. This may be due to low number of cadaver donations because of religious beliefs, and also due to costs. However, best efforts should be given to obtain human temporal ears for the ideal training. Sheep ear study can be a complementary model to human temporal bone studies but can never replace it.

We have been using sheep temporal bone as a model for otologic training since 2003. Due to lack of a pneumatized mastoid it has no value for mastoidectomy procedures. We found it valuable for training in transcanal approaches, exploratory tympanotomy, orientation to facial nerve in the middle ear, myringotomy, ossiculoplasty and especially for stapedectomy. Before beginning to stapes surgery sheep ear is used as a model by our residents in order to gain orientation to middle ear structures especially to facial nerve, ossicles and oval window. It is clear that the most challenging portion of the stapes surgery is the fenestration of the oval window. A small mistake at this time can lead to disastrous results and complete loss of hearing in the operated ear. There was a limitation on this study. It might be ideal to compare results of stapedectomy on patients performed by residents whose learning curve began with “sheep cadaver ear teaching module” to other residents who did not train with this module. To analyse a learning curve it must include at least 50 stapedectomy procedures. There is a worldwide concern about the declining number of stapedectomy operations. It is clear that it may take many years to obtain great numbers of cases for such series.

Conclusion

We recommend using sheep ear model for stapedectomy training as the first step of learning curve. We believe it will speed up the stapedectomy learning curve safely.

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