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Study on goat as animal model for endoscopic sinus surgery training

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Background: Endoscopic sinonasal surgery (ESS) is a technically challenging surgery and concerns exist regarding patient safety early in the surgeon’s learning curve because of its complications. Developing models with endoscopic appearance of the nasal airway closely resembling real human tissue was necessary to allow the same ESS steps to be performed as in real life.

Objective: To carry out anatomic study on paranasal sinuses in goats, by means of Computerized tomography and endoscopic dissection technique to assess the possibility of using goats as a model for ESS training to allow trainees in nasal and sinus endoscopy to develop basic instrument handling and psychomotor skills.

Methods: Computerized tomography was done for the goat skulls. ESS is done in the form of uncinctomy, maxillary sinus opening, ethmoidectomy and frontal sinus exploration with a special focus on the possibility of its use in training.

Results: The endoscopic appearance of the nasal airway and paranasal sinuses of goats is reasonably similar to humans in morphological anatomy and structure. The thickness of goat sinus mucosa also showed enough consistency to carry out the endoscopic sinus surgical technique.

Conclusions: Goat is a suitable study model in learning endoscopic sinus surgery.

Keywords: Functional Endoscopic Sinus Surgery (FESS), animal model, residency training, paranasal sinuses in goats.

INTRODUCTION

Endoscopic sinonasal surgery (ESS) popularity has increased significantly since it was created by Messerklinger in the late 1970s,1 with a rapid proliferation since it was introduced in America in the late 1980s by Kennedy and Stammberger.2,3 Endoscopic sinonasal techniques have become a very important tool in the surgical treatment of inflammatory sinonasal pathologies and a great variety of tumours, lesions of the skull base,4 dacryocystorhinostomy.5 Although endoscopic sinonasal surgery is a minimally invasive technique, concerns exist regarding patient safety especially early in the surgeon’s learning curve because of its complications.6,7 It requires a high level of training, as well as a great knowledge of the nasal anatomy and its clinical and radiological correlation. Residents must be progressively and constantly instructed by a specialist during their years of training to acquire the necessary skills to perform this surgery.4

Developing models with endoscopic appearance of the nasal airway closely resembling real human tissue was
necessary to allow the same ESS steps to be performed as in real life. Models provide a 3-dimensional educational experience in which dynamic views of structures and their spatial relationships can be explored. In recent years, models have emerged to be used for this purpose as cadavers, animals and virtual reality simulators. We believe that animal models are the most suitable ones for ESS training in our locality because of the cadavers' costs and scarcity; also virtual reality simulators have an elevated cost.

Sheep have long been used as models for ESS because of their similarity to human tissues. Sheep needs slight modification to simulate more closely the human situation. The investigation on new animal models is necessary to allow efficient training on ESS.

Goats are a popular large animal model because they can be easily obtained and easily bred. Over the past decades, they have been used to study immunosorology, microbiology, biological products, gene transfer and tissue-engineering repair of bony defects. There were also a few maxillary sinus floor elevation reports using this model. However, they were not used as a model for ESS training.

This present work has as goal to carry out anatomic study of paranasal sinuses in goats, by means of CT and endoscopic dissection techniques to assess the possibility of using goats as a model for ESS training to allow trainees in nasal and sinus endoscopy to develop basic instrument handling and psychomotor skills.

**PATIENTS AND METHODS**

This study was carried out in Assiut University Hospital in the period from November 2008 to July 2010. Fifteen goat skulls were used in this study. To assess the anatomy of goat's paranasal sinuses and its resemblance to that of human, we started with five goat skulls by doing Multidetector Computerized Tomography-64 for the specimens, with coronal, axial and sagittal cuts, bone window, 0.6 mm thickness without contrast (Fig. 1). Then endoscopic surgical anatomical study of paranasal sinuses was done on them, trying to prove the feasibility of carrying out the necessary surgical access to paranasal sinuses. Surgical steps of endoscopic sinus surgery were done in the form of uncinectomy, maxillary sinus opening, ethmoidectomy and frontal sinus exploration with the use of 30° 2.7 mm rigid endoscope (Karl Storz, Germany, Tuttingen) coupled to a digital camera (Karl Storz, Germany, Tuttingen). Sickle knife was used to incise the uncinate (Fig. 2a), uncinectomy was completed by straight grasping forceps (Fig. 2b,c). Opening of the dorsal sinus of the middle concha (Fig. 3a), ethmoidectomy (Fig. 3b) and frontal sinus exploration were done by upward biting forceps, together with the help of frontal sinus seeker to open the frontal sinus (Fig. 4).

To evaluate the possibility of using goats as a model for ESS, a residency training program was arranged in Endoscopy Unit in the Quality Assurance Unit in Assiut University and trainees performed endoscopic dissection of paranasal sinuses of ten goat skulls (twenty nasal sides) under the supervision of experienced endoscopic sinus surgeons. All the steps were monitored for evaluation of the trainees.

**RESULTS**

We identified the main Sinuses in Goats by CT and ESS (maxillary, ventral conchal, middle conchal, dorsal conchal and frontal) (Figs. 1-4) In general, the paranasal sinuses in goats fall into two groups, the first group includes maxillary and palatine sinuses. The maxillary sinus is present in the maxillary and zygomatic bones and in the bulla of lacrimal bone. It is in wide communication with palatine sinus, with which it shares the nasomaxillary aperture into the middle meatus. The nasomaxillary aperture is narrowed by the uncinate process. On the other hand, the second group comprises independent sinuses which open separately into the nasal cavity. This group includes dorsal, middle and ventral nasal sinuses or meatuses which result from division of nasal cavity by dorsal and ventral conchae. It also includes medial and lateral frontal sinuses which open separately into the ethmoidal meatuses situated between nasal septum and nasal conchae. They open through orifices in the dorsal ethmoidal region. The lacrimal sinuses also do or they may be a part of the lateral frontal sinuses. Sphenoid sinuses are not present in small ruminants.

Since the caudal ends of the dorsal and middle nasal conchae in ruminants are parts of the ethmoidal conchae and are known as endoturbinates I and II respectively, we suggest that middle turbinateotomy done by some researchers is not necessary. We can access the frontal sinus directly by dissecting the middle concha. On the other hand, the maxillary sinus can be reached directly by incising the uncinate process without the need of middle concha dissection.

The goats have paranasal sinuses reasonably similar to humans in morphological anatomy and structure. The thickness of goat sinus mucosa also showed enough consistency to carry out the endoscopic sinus surgical technique. Moreover, the evaluation of the trainees in residency training program showed the suitability of goats for training in ESS.
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Fig 1. Computed tomography of paranasal sinuses of goats. (A) Coronal cut showing frontal sinuses (B) Axial cut showing conchal sinuses.

Fig 2. Endoscopic views of uncinectomy and middle meatal antrostomy of goats. (A): Sickle knife “S” used to incise the uncinate “U”. (B) Straight grasping forceps “F” used to complete uncinectomy and widen maxillary sinus ostium. (C) Showing maxillary sinus “M” after widening of the ostium.
Fig 3. Endoscopic views of ethmoidectomy. (A): Upward biting forceps "UF" used to open the dorsal sinus of the middle concha. (B): Opening of the ethmoid air cells "E" by upward biting forceps.

Fig 4. Endoscopic views of frontal sinus exploration. (A): Frontal sinus seeker "SE" used to open the frontal sinus "FS". (B): Upward biting forceps "UF" used to complete opening of the frontal sinus "FS". (C): Showing the lateral frontal sinus ostium "LFO" after widening.
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**DISCUSSION**

Endoscopic sinonasal surgery is a minimally invasive surgical technique. However, concerns exist regarding patient safety early in the surgeon's learning curve because of its complications. Developing models with endoscopic appearance of the nasal airway closely resembling real human tissue was necessary. In recent years, models have emerged to be used for this purpose as cadavers, animals and virtual reality simulators. Sheep have long been used as models for ESS because of their similarity to human tissues. Goats are easily obtained, easily bred. We carried out anatomic study of paranasal sinuses in goats, by means of CT and endoscopic dissection techniques to assess the possibility of using goats as a model for ESS training to allow trainees in nasal and sinus endoscopy to develop basic instrument handling and psychomotor skills. The goats have paranasal sinuses reasonably similar to humans in morphological anatomy and structure. The thickness of goat sinus mucosa also showed enough consistency to carry out the endoscopic sinus surgical technique. Moreover, the evaluation of the trainees in residency training program showed the suitability of goats for training in ESS. The external nose of goats is somewhat shorter than that of sheep, making endoscopic access to paranasal sinuses easier in goats. The results of this study show that the goat is a suitable model in helping residents to learn basic instrument handling and psychomotor skills in ESS.

**CONCLUSIONS**

Goat is a suitable study model in helping residents to learn endoscopic sinus surgery.

**RECOMMENDATIONS**

According to a comprehensive analysis of paranasal sinuses, we recommend using the goat model in training for endoscopic sinus surgery.

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