The Lamb's Head as a Model for Surgical Skills Development in Endonasal Surgery

Luíza Baptista Mallmann¹ Otávio Bejzman Piltcher^{2,3} Gustavo Rassier Isolan^{1,4}

¹Post-graduate Program in Medicine: Surgical Sciences, Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, RS, Brazil

²Otolaryngology Service, Hospital de Clínicas de Porto Alegre (HCPA), Porto Alegre, RS, Brazil

³Universidade Federal do Rio Grande do Sul (UFRGS), School of Medicine, Porto Alegre, RS, Brazil

⁴Neurosurgery Service, Hospital de Clínicas de Porto Alegre (HCPA), Porto Alegre, RS, Brazil

Address for correspondence Gustavo Rassier Isolan, MD, PhD, Post-Graduate Program in Medicine: Surgical Sciences, Universidade Federal do Rio Grande do Sul (UFRGS), Rua Ramiro Barcelos 2400, 2º andar, 90035-003 - Porto Alegre, RS, Brazil (e-mail: gisolan@yahoo.com.br).

J Neurol Surg B 2016;77:466–472.

Abstract

Objectives To test the viability of a lamb's head model for sinonasal surgery training in Brazil by comparing performance of endoscopic procedures in the septum and inferior turbinates.

Design Prospective study.

Settings Universidade Federal do Rio Grande do Sul (2015).

Participants Ten physicians performed septoplasty, inferior turbinoplasty, and middle turbinectomy on 30 lamb's heads.

Main Outcome Measures Degree of difficulty and similarity, opinion of tissue color and texture, and degree of satisfaction.

Results Participants completed a questionnaire at the end of each procedure and a satisfaction survey at the end of the project. Significant between-group differences were found for the perceived degree of difficulty in performing left inferior turbinoplasty, right inferior turbinoplasty, and septoplasty. Final satisfaction with training was scored 9 out of 10, and all participants reported that they would like to receive such training again.

Conclusion The tested model is feasible due to its low cost, its easy availability, and its similarity to human anatomy in terms of dimensions of relevant structures and tissue consistency. It allows effective training in instrument handling and acquisition of the surgical skills related to two-dimensional vision needed for endoscopy. However, it should not be considered a substitute for training of specific surgical techniques.

Keywords

- paranasal sinus
- animal model
- training technique
- surgery
- education

Introduction

Endoscopic sinonasal surgery was created in Austria in the 1970s through the studies of Messerklinger^{1–3} and gained popularity with the work of Stammberger in 1984 and Kennedy in 1985^{1,4}; it is now considered the gold standard for treatment of surgical conditions of the nose and paranasal

sinuses.⁵ Proper execution of endonasal surgery requires knowledge of not only nasal, paranasal, and skull base anatomy but also the techniques to be used and training in their adequate performance.^{6–9}

The learning curve is long and many complications are possible.⁷ This so-called learning period—the period during which surgeons acquire surgical skills and experience—depends

received

November 6, 2015

accepted after revision

March 15, 2016

published online

May 2, 2016

© 2016 Georg Thieme Verlag KG
Stuttgart · New York

DOI <http://dx.doi.org/10.1055/s-0036-1583186>.
ISSN 2193-6331.

on the complexity of the technique, the surgeon's innate ability, and the quality of training provided.^{10,11} Furthermore, because of the inherent characteristics of endoscopic procedures, in which the surgeon has no three-dimensional vision—unlike that provided by normal human eyesight or during microscopic visualization—the learning curve also involves development of a skill for determining the orientation of surgical instruments in space. One technological aid available is image guidance, which has been providing surgeons with improved anatomical localization during procedures; however, this tool is no substitute for medical training.⁸

Historically, surgical training took place during daily practice, on live patients, during live surgery presentations, or in dissection laboratories.^{12,13} However, ethical questions have been raised regarding the surgeon's dependence on such intraoperative training, due to the high rate of attendant complications.^{7,12}

Cadaver laboratories are currently considered the optimal method for training in surgical techniques. However, their use is becoming progressively infeasible due to legal and ethical issues.¹⁴

This has prompted a constant search for alternative means of developing endoscopic surgery skills. Reported alternatives include simulators,^{13,15} anatomical models,^{12,16,17} and animal models.^{18,19} In 1996, Gardiner et al reported the use of sheep's heads—which, although larger than human heads, have a similar nasal anatomy—for acquiring surgical skills and learning basic procedures.¹⁸ In 2011, Mladina et al published a study on the use of lamb's heads, which are closer in size to human heads¹⁹; in 2013, a major medical equipment manufacturer, recognizing the potential of this model, published a dissection guide.²⁰

In terms of the nasal septum, the comparative anatomy of the lamb is very similar to that of humans. The structures of the lateral wall are similar but not identical to those of humans,²¹ whereas the middle turbinate, in terms of both spatial orientation and attachment to the lateral wall and skull base, is more similar to its human counterpart.^{20,22} On endoscopy, two structures are visible upon entry into the lamb nasal fossa: one that resembles the human inferior turbinate and one analogous to the middle turbinate. In veterinary terminology, the structure that resembles the human middle turbinate is known as the *concha ventralis*, which corresponds to the inferior turbinate; this structure comprises two portions: the superior *pars dorsalis* and the inferior *pars dorsalis*. The term *middle turbinate* in the lamb corresponds to a deeper structure, which can only be visualized properly if the inferior turbinate is removed; the corresponding structure is known as the *plexus cavernosus nasalis*, a cavernous plexus of the nasal mucosa^{20,22} (►Fig. 1).

In light of the difficulties of teaching through cadaver dissection and the importance of finding ways to shorten the learning curve of sinonasal surgery without exposing untrained surgeons to live patients, the present study sought to assess the lamb head model proposed by Mladina for performance of septoplasty, inferior turbinoplasty, and middle turbinectomy by residents and staff physicians of a teaching hospital in Southern Brazil.²⁰

Fig. 1 Endoscopic view of the lamb's left nasal fossa. 1 *Concha dorsalis*, 2a *concha ventralis superior pars dorsalis*, 2b *concha ventralis inferior pars dorsalis*, 3 septum.

Materials and Methods

Techniques for use of the lamb's head model followed the protocol advocated by Mladina.²⁰ Thirty lamb's heads were acquired from a supplier accredited by the Animal Experimentation Unit at Hospital de Clínicas de Porto Alegre, Brazil, and frozen at -15 to -20°C . Before use, the heads were thawed for 8 hours at 22°C or 12 to 16 hours at 5 to 6°C , and subsequently mounted onto a holder (►Fig. 2).

No sample size calculation was performed. The participants of this study were eight⁸ residents in the early stages of nasal surgery training and two² staff physicians, all affiliated with the Otolaryngology Service of Hospital de Clínicas de Porto Alegre. Each participant was given three heads (six nasal fossae) on which to practice, for a total of 30 procedures assessed. The questionnaire one was completed immediately after performance of each procedure and another questionnaire was administered only once to each participant, at the end of the data collection period.

Thus, four first-year residents (group R1) and four second-year residents (group R2) performed a set of preestablished tasks, as did two surgeons with experience in sinonasal surgery (staff group, S), at the Animal Experimentation Unit, Hospital de Clínicas de Porto Alegre. Participants completed a questionnaire about the degree of difficulty found, their opinion of tissue quality, and their opinion of the similarity between lamb and human nasal anatomy. They also assigned each procedure (bilateral inferior turbinoplasty and septoplasty) a score of 1 to 3, with 1 = not performed, 2 = performed incompletely or inadequately, or 3 = performed satisfactorily. At the end of the project, participants completed a satisfaction survey, designed to collect their opinions regarding the type of training provided, whether they would participate in such training again and how many times a year they believed it would be useful, whether they were willing to pay for such training, and how much (up to US \$250, US \$250–500, US \$500–1,000, or > US \$1,000), and

Fig. 2 Lamb's head fixated within holder and positioned for the study procedures.

whether handling of endoscopic instrumentation, handling of conventional surgical instrumentation, septoplasty, inferior turbinoplasty, and middle turbinectomy were comparable with human cadaver dissection. Finally, they were asked to grade their overall experience.

Participants were asked to follow the technique for inferior turbinoplasty and middle turbinectomy described as follows:

1. Resect superior part of the inferior turbinate (*concha ventralis*) with scissors, mimicking a turbinectomy procedure
2. Using the remaining inferior turbinate (*concha ventralis pars dorsalis inferior*), which should now be very similar to a human inferior turbinate, fashion a mucous flap from the superior part, remove any exposed bone, and reposition the flap in place, mimicking a turbinoplasty
3. Amputate the *concha ventralis pars dorsalis* superior, leaving only its tail, mimicking a middle turbinectomy

The proposed septoplasty technique was as follows:

1. Infiltrate septal mucosa with saline solution using a syringe and needle
2. Delimit sites of vertical and horizontal septal incision with a Freer elevator
3. Incise septal mucosa with a No. 5 scalpel blade as necessary
4. Elevate the septal mucosa down to the bony transition
5. Cut cartilage and remove fragment
6. Reposition flap

Landmarks to be identified:

- *Concha ventralis* and its parts: inferior and superior *pars dorsalis*

To assess the characteristics of the model, tissue color and texture were taken into account.

Color could be assessed as:

- Dark, when more intensely pigmented than living tissue
- Normal, when similar to that of living tissue
- Pale, when lighter than living tissue

Texture could be assessed as:

- Normal, when similar in consistency to living tissue
- Friable, when tissues were slightly autolyzed or fragile, without jeopardizing performance of the surgical procedure

For statistical analyses, quantitative variables were expressed as medians and ranges, and categorical variables, as absolute and relative frequencies.

The Kruskal-Wallis test was used for comparison of numerical variables between groups. When differences were statistically significant, the Mann-Whitney *U* test was applied as well. Fisher's exact test was used for categorical variables.

The significance level was set at 5%, and all analyses were performed in SPSS 21.0 (IBM Corporation Armonk, New York, US).

This study was approved by the Institutional Animal Care and Use Committee of Hospital de Clínicas de Porto Alegre.

All procedures were performed in accordance with Brazilian Law No. 11,794 of October 8, 2008, which sets forth guidelines for animal use in research, and CONCEA (National Council of Animal Experimentation Control) Resolution No. 12, establishing the "Brazilian Guideline for the Care and Use of Animals for Scientific and Educational Purposes."

All relevant safety standards and good laboratory practices were followed.

Biological waste was discarded into white plastic bags rated as appropriate for the disposal of biohazard waste. All solid chemical waste (gloves, tips, and tubes impregnated with chemical residue) were discarded into plastic bags, and liquid chemical waste was discarded into labeled plastic gallon jugs.

After use, lamb heads were stored in white plastic bags and frozen at -80°C . All waste disposal was performed in accordance with routine Hospital de Clínicas de Porto Alegre practices for hospital waste management.

Results and Analysis

Dissections were performed at the Hospital de Clínicas de Porto Alegre Animal Experimentation Unit between January 5, 2015 and March 4, 2015. Dissections took place twice weekly (two sessions per day).

Procedures were performed by four first-year ENT residents (group R1), four second-year ENT residents (group R2), and two staff otolaryngologists (group S), all affiliated with Hospital de Clínicas de Porto Alegre.

The materials available for dissection included a 4-mm, 0-degree Storz scope, three Freer elevators, Metzenbaum scissors, a scalpel handle with No. 15 blade, a suction elevator, a Frazier suction tube, two Bruening forceps, and a cartilage knife. All procedures were recorded.

Results were initially tabulated by group and evaluation. Because of absence of statistically significant differences across groups, the three evaluations (one provided by each group) were pooled for analysis, with each group remaining separate. As final evaluation was performed individually by each participant, all participants were pooled in a single group for analysis.

Regarding the scores assigned to ease in locating landmarks (scale of 0–10, with 10 denoting "no difficulty

whatsoever”) and degree of anatomical similarity (scale of 0–10, with 10 denoting “similar to human anatomy”), groups were homogeneous for the structure that resembles the middle turbinate analogue (*concha ventralis*), with no significant differences. The lamb's nasal septum was regarded as very similar to the human septum by all groups, with a median score of 10 (►Table 1).

Regarding difficulty in carrying out the proposed tasks, significant differences were found between groups R1 and R2 and between these groups and group S for left inferior turbinoplasty ($p = 0.019$) and right inferior turbinoplasty ($p = 0.007$). The resident physician groups reported greater difficulty than the staff physician group, demonstrating the difference in experience between them. For septoplasty, the Mann-Whitney U test revealed differences across all groups ($p < 0.001$), with decreasing difficulty as experience increased: participants in group R1 never performed endoscopic septoplasty, those in group R2 had 1 year of experience, and those in group S had over 5 years of training (►Table 1).

There were no statistically significant differences among the groups regarding participants' opinions of tissue color and texture. Those in group S found no differences between the model and human cadaver tissue. Those in group R1 evaluated six heads as paler than human tissue and two as more friable, whereas participants in R2 reported five heads as pale in relation to human tissue and one as hardened (a characteristic not provided for in the evaluation questionnaire) (►Table 2).

The median satisfaction score after each procedure (scale of 1–3, with 3 denoting “complete satisfaction”) was greater than 2 across all groups. Group R1 participants reported lower satisfaction after performance of right inferior turbinoplasty than after other procedures. Participants in group S reported complete satisfaction with all proposed procedures, with no significant differences (►Table 3).

Table 2 Comparison of participant opinions regarding tissue color and texture between evaluations, stratified by group

Variable	Group R1 (n = 12)	Group R2 (n = 12)	Group S (n = 6)	p^a
	n (%)	n (%)	n (%)	
Tissue color (pale)	6 (50.0)	5 (41.7)	0 (0.0)	0.104
Tissue texture (friable or hardened)	2 (18.2)	1 (8.3)	0 (0.0)	0.479

^aFisher's exact test.

Final satisfaction scores—measured after all participants had completed the study and e-mailed their responses—consisted of a single grade assigned by each participant. The median score assigned by participants regarding their opinion of training was 9 (on a scale of 0–10). When asked whether they would repeat the procedure, all participants responded they would, at least twice a year (the question on how many times a year they would repeat training was open-ended). One participant manifested a willingness to redo training once a week. Participants were also asked whether they would pay to take a surgical skills training course using the lamb's head model, taking into account that similar courses performed using human cadavers cost approximately US \$1,000. Again, all participants responded they would; seven participants replied they were willing to pay up to US \$250 and three would pay US \$250 to 500 (►Table 4).

On comparison between procedures in humans and in lambs, handling of video nasoendoscopy instruments was considered similar by participants in all groups, with a median score of 10. Handling of conventional nasal surgical instruments was considered identical to their manipulation

Table 1 Comparison of the degree of difficulty and degree of similarity between evaluations, stratified by group, considering evaluations

Variable	Group R1 (n = 12)	Group R2 (n = 12)	Group S (n = 6)	p^a
	Median (range)	Median (range)	Median (range)	
Degree of difficulty				
Landmark: <i>Concha ventralis</i> and its parts	2 (0; 8)	5 (0; 10)	1 (0; 5)	0.119
Left inferior turbinoplasty	6.5 (1; 8) ^c	7 (3; 10) ^c	2.5 (0; 5) ^b	0.019
Right inferior turbinoplasty	6 (4; 10) ^c	7 (4; 9) ^c	2.5 (2; 5) ^b	0.007
Septoplasty	6.5 (1; 9) ^d	3 (0; 7) ^c	0 (0; 1) ^b	< 0.001
Degree of similarity				
<i>Concha ventralis</i> inferior pars dorsalis	6 (0; 8)	4.5 (2; 8)	5.5 (4; 10)	0.130
<i>Concha ventralis</i> superior pars dorsalis	5 (0–8)	5 (4–8)	3.5 (1–5)	0.187
Nasal septum	10 (7; 10)	10 (8; 10)	10 (9; 10)	0.463

^aKruskal-Wallis test.

^{b,c,d}Same superscript letter denotes no significant difference at the 5% level (Mann-Whitney U).

Table 3 Degree of satisfaction immediately after the procedure

Variable	Group R1 (n = 12)	Group R2 (n = 12)	Group S (n = 6)	p ^a
	Median (range)	Median (range)	Median (range)	
Left inferior turbinoplasty	2.5 (1; 3)	2 (1; 3)	3 (2; 3)	0.216
Right inferior turbinoplasty	2 (1; 3)	2 (2; 3)	3 (2; 3)	0.056
Septoplasty	3 (2; 3)	3 (2; 3)	3 (3; 3)	0.761

^aKruskal-Wallis test.

in humans. The median score for septoplasty was 9, denoting near-complete similarity to the procedure as performed in humans; inferior turbinoplasty had a median score of 7, demonstrating partial similarity. In all groups, the lowest acceptance reported was for handling of the structure *concha ventralis* superior *pars dorsalis*, with a median score of 5, denoting little similarity to the human structure (→Table 4).

Finally, participants were asked to assign a final score to the proposed procedures. The median of the 10 participants was a score of 9.

Discussion

For several reasons, endoscopic sinus surgery has brought countless benefits to patients in whom surgical treatment is indicated.⁶ With the dissemination of these techniques since 1980, training in their performance has become indispensable. The learning curve is long, and many possible risks are involved in these procedures.⁷ This has led to a search for ways to control training and for alternatives to the use of human cadavers; access to the latter is highly restricted for legal reasons, although they are known to be the optimal training model.

Table 4 Final satisfaction

Variable ^a	Overall
Opinion of training	9 (8; 10)
Would participate in training again	10 (100)
How many times?	2 (2; 48)
Would pay for training	10 (100)
How much?	
Up to US \$250.00	7 (70.0)
US \$250 to US \$500	3 (10.0)
Comparison of model with humans	
Endoscopic instrumentation handling	10 (9; 10)
Conventional surgical instrumentation handling	10 (7; 10)
Septoplasty	9 (6; 10)
Inferior turbinoplasty	7 (2; 9)
Manipulation of the <i>concha ventralis</i> <i>pars dorsalis</i> superior	5 (3; 8)
Final score	9 (8; 10)

^aVariables expressed as median (range) or n (%).

Many studies have sought to evaluate the training of physicians involved in endonasal surgery. Proposals have ranged from limiting handling of human patients to physicians who have trained on a minimum number of cadavers, documenting supervision by instructors, number of dissection courses taken, several control processes, and acting on adverse events attributable to these procedures.⁶

The time necessary for physicians in the field to feel confident in performing these procedures has also been established. Corroborating the difficulty of the learning curve, authors have reported times of 6 months for the mere handling of 0-degree scopes and up to 2 years for recognition of structures in operated cavities.²³

Several models have been developed in response to this unquestionable need for training. In 2007, Briner et al conceived of a plastic model of the nose and paranasal sinuses made from molded silicone rubber slices and two-component polyurethane.¹⁶ In 2012, Burge et al reported on a silicone matrix model that enabled reproduction of anatomic details.¹² In 2011, a Georgetown University group presented their training model, constructed using a gelatin powder and water-based gel substrate at a cost of less than US \$5.^{13,24,25} All these models enabled significant improvement in the surgeon's performance to be achieved with repeated practice. However, all have limitations in terms of texture, presentation of anatomic variants, and presence of structures such as vessels and nerves.

In 2008, in Brazil, Nogueira et al created an anatomical model made from Neoderma (a material that simulates the consistency of human tissue and mucous membranes) and resin. The authors produced models containing a nasal septum; inferior, middle, and superior turbinates; uncinate process; lamina papyracea, maxillary, frontal, ethmoid, and sphenoid sinuses; ethmoid bulla; orbital contents; intersinus septum in the sphenoid sinus; and sella turcica with pituitary tumor. This model was named SIMONT—Sinus Model Otorrino-NeuroTrainer (Recife, Brazil)—and, with some enhancements, it remains in use with great acceptance as a training aid at Centro de Otorrino e Fonoaudiologia de São Paulo.¹⁷

Another alternative for surgeon training was the development of simulators, created with the rationale of filling the gap between theory and practice by providing a safe environment for surgeons to become familiar with anatomy and practice operative skills. Several research groups have launched their own simulators: the VOXEL-MAN endonasal surgery simulator (University Medical Center Hamburg-Eppendorf, Germany); the ES3 Endoscopic Sinus Surgery Simulator (Lockheed Martin, Ohio, United States); and the

Stanford Rhinological Virtual Surgical Environment (Stanford University, Stanford, California, United States).¹⁵ Despite the availability of these simulators and the reality of robotic surgery, further improvements and validation are still required in the field of sinonasal surgery.⁹

The animal model as training alternative was first used in 1996 by Gardiner et al, who tested the use of sheep's heads,¹⁸ followed by Mladina some years later; Mladina, however, substituted lamb for sheep, justifying the change due to the greater similarity in nasal cavity size between young sheep and humans.^{19,20} Recently, Awad et al published the first and largest study to prospectively examine skills acquired with an animal model (sheep's head), with discrimination of the different experience levels of 114 participants over an 18-month period; the authors reported results equally indicative of the successful use of this model for endoscopic sinonasal surgery training.⁵

Endoscopic septoplasty was described in the early studies by Gardiner et al.¹⁸ The procedure is considered highly similar to that performed in humans. It allows surgeons to practice infiltrating and freeing the septal mucosa and incising cartilage without injury to the contralateral mucoperichondrium. Another training modality, recently described by Mladina in a yet-unpublished article, involves raising septal mucoperichondrial flaps, which are widely used in contemporary skull base surgery. Conventional septoplasty, which is more common in practice, is difficult to perform in the lamb's head model because it necessitates partial removal of the animal's snout for introduction of surgical and endoscopic instruments and leaves the cartilage exposed.

Gardiner et al¹⁸ also demonstrated training of endoscopic inferior turbinectomy in sheep. Until recently, Mladina did not propose training of procedures in the *concha ventralis*,^{19,20} nor did Awad et al.⁵ In the present study, inferior turbinoplasty—despite a high degree of participant satisfaction with bilateral procedures—was considered only slightly similar to the procedure in humans, due to the bony instability of the structure and to the presence of a small bone that is found in lambs after removal of the superior portion of this structure. On the other hand, removal of this structure allows the surgeon to practice handling turbinectomy scissors.

Manipulation of the structure *concha ventralis* superior *pars dorsalis* was considered to bear little similarity to the procedure in humans. In his work, Mladina never mentioned this step during procedures, probably due to the aforementioned anatomical issue.^{19,20} The value in manipulating this structure is as an opportunity for practicing use of the endoscope and instruments rather than for training of an actual surgical skill, and largely for enhancement of the surgeon's ability to remove the posterior part of the structure; in this sense, it resembles the middle turbinate technique in humans, which is known to be one of the most difficult steps of the procedure.

Although this study provided an interesting opportunity to evaluate differences in technique through surgical models, the small number of participants ($n = 10$) precluded assessment of statistical impact across groups. However, as the

overarching objective of the present study was to evaluate the training model itself, the identification of unanimously high approval by all participants gives the authors hope that this model may prove to be an excellent alternative for initial training of ENT residents, particularly for acquisition of technical skills, development of depth perception during two-dimensional vision, and learning to operate the various surgical instruments used in this specialty. Evidently, this model cannot be considered a substitute for human cadavers, due to anatomical differences, which limit its utility for training of surgical techniques.

Enthusiasm for this model is also related to its low cost. In the present study, the total cost of each head was US \$33, which is an unquestionably affordable figure for a surgical training aid. As sheep are widely raised for their meat and lamb's heads are often discarded at meat packing plants, the ease of procurement and absence of ethical limitations to its use make this model even more appealing.²⁶

As also proposed by Mladina²⁰ and Awad et al,⁵ we recommend that long-term studies with a larger number of participants be performed to assess this animal model with respect to manipulation of the maxillary, anterior ethmoid, and frontal sinuses, as well as the orbits.

Ours was the first study to evaluate the use of the lamb's head model for sinonasal surgery training in South America. Participants' responses allow us to conclude that this model is viable not only for its low cost and widespread availability but also for its similarity to human anatomy in terms of dimensions of relevant structures and tissue consistency, which allow effective training in instrument handling and acquisition of skills related to operating with two-dimensional vision, which are essential for the practice of endoscopic surgery.

Acknowledgments

The authors thank Amanda Lucas da Costa, Camila Degen Meotti, Fabio André Selaimen, João Augusto Polesi Bergamaschi, Konrado Massing Deutsch, Luís Rabaoli, Manoela Paiva de Oliveira, Marcel Machado Valério, Paula de Oliveira Oppermann, and Raphaella de Oliveira Migliavacca for their support; the staff at the Animal Experimentation Unit, Hospital de Clínicas de Porto Alegre: Marta Justina Giotti Cioato, Fernanda Soldatelli Valente, Tuane N. Alves Garcez, Sonia M. P. Rodrigues, and Rosalina A. Braga; Strattnr; and the Graduate Program in Surgical Sciences, Universidade Federal do Rio Grande do Sul.

Special acknowledgment goes to Prof. Ranko Mladina, who created the lamb model, for being so available in sharing information.

Financial support for this study was provided by the Fund for Research and Event Promotion (FIPE) of Hospital de Clínicas de Porto Alegre (grant number US \$100,000)

References

- Shankar L, Evans K. An Atlas of Imaging of Paranasal Sinus. USA: Taylor & Francis; 2006

- 2 Leunig A. Cirugía endoscópica de la pared nasal lateral, de los senos paranasales y de la base anterior del cráneo. Tuttlingen, Germany: Straub Druck, Medien AG; 2009
- 3 Kennedy DW, Zinreich SJ, Rosenbaum AE, Johns ME. Functional endoscopic sinus surgery. Theory and diagnostic evaluation. *Arch Otolaryngol* 1985;111(9):576–582
- 4 el-Hennawi DM. Combined functional endoscopic sinus surgery (FESS): a revisited approach. *Rhinology* 1998;36(4):196–201
- 5 Awad Z, Taghi A, Sethukumar P, Tolley NS. Construct validity of the ovine model in endoscopic sinus surgery training. *Laryngoscope* 2015;125(3):539–543
- 6 McFerran DJ, Grant HR, Ingrams DR, Fife DG. Endoscopic sinus surgery: are junior doctors being properly trained? *Ann R Coll Surg Engl* 1998;80(5):359–363
- 7 Snyderman C, Kassam A, Carrau R, Mintz A, Gardner P, Prevedello DM. Acquisition of surgical skills for endonasal skull base surgery: a training program. *Laryngoscope* 2007;117(4):699–705
- 8 Zuckerman JD, Wise SK, Rogers GA, Senior BA, Schlosser RJ, DelGaudio JM. The utility of cadaver dissection in endoscopic sinus surgery training courses. *Am J Rhinol Allergy* 2009;23(2):218–224
- 9 Wais M, Ooi E, Leung RM, Vescan AD, Lee J, Witterick IJ. The effect of low-fidelity endoscopic sinus surgery simulators on surgical skill. *Int Forum Allergy Rhinol* 2012;2(1):20–26
- 10 Sachdeva AK, Russell TR. Safe introduction of new procedures and emerging technologies in surgery: education, credentialing, and privileging. *Surg Clin North Am* 2007;87(4):853–866, vi–vii vi–vii.
- 11 Isolan GR. [The young neurosurgeon learning curve: ethical, scientific, philosophical aspects and the importance of the microsurgical laboratory training]. *J Bras Neurocirurg* 2009;20(3):314–344
- 12 Burge SD, Bunegin L, Weitzel EK, McMains KC. The validation of an endoscopic sinus surgery skills training model: a pilot study. *Am J Rhinol Allergy* 2012;26(5):409–413
- 13 Steehler MK, Chu EE, Na H, Pfisterer MJ, Hesham HN, Malekzadeh S. Teaching and assessing endoscopic sinus surgery skills on a validated low-cost task trainer. *Laryngoscope* 2013;123(4):841–844
- 14 8.501 L. No Title. 1992 [Internet]. www.planalto.gov.br/ccivil_03/Leis/L8501.htm. Accessed: October 2015
- 15 Clifton N, Klingmann C, Khalil H. Teaching Otolaryngology skills through simulation. *Eur Arch Otorhinolaryngol* 2011;268(7):949–953
- 16 Briner HR, Simmen D, Jones N, et al. Evaluation of an anatomic model of the paranasal sinuses for endonasal surgical training. *Rhinology* 2007;45(1):20–23
- 17 Nogueira JF, Stamm AC, Lyra M, Balieiro FO, Leão FS. Building a real endoscopic sinus and skull-base surgery simulator. *Otolaryngol Head Neck Surg* 2008;139(5):727–728
- 18 Gardiner Q, Oluwole M, Tan L, White PS. An animal model for training in endoscopic nasal and sinus surgery. *J Laryngol Otol* 1996;110(5):425–428
- 19 Mladina R, Vuković K, Štern Padovan R, Skitarelić N. An animal model for endoscopic endonasal surgery and dacryocystorhinostomy training: uses and limitations of the lamb's head. *J Laryngol Otol* 2011;125(7):696–700
- 20 Mladina R. Endoscopic Surgical Anatomy of the Lamb's Head. Germany: Endo Press; 2013
- 21 Dalgorf DM, Harvey RJ. Chapter 1: sinonasal anatomy and function. *Am J Rhinol Allergy* 2013;27(Suppl 1):S3–S6
- 22 Sisson S, Grossman J. Anatomia dos animais domésticos. Brazil: Guanabara Koogan; 1986
- 23 Bakker NH, Fokkens WJ, Grimbergen CA. Investigation of training needs for functional endoscopic sinus surgery (FESS). *Rhinology* 2005;43(2):104–108
- 24 Malekzadeh S, Pfisterer MJ, Wilson B, Na H, Steehler MK. A novel low-cost sinus surgery task trainer. *Otolaryngol Head Neck Surg* 2011;145(4):530–533
- 25 Steehler MK, Pfisterer MJ, Na H, Hesham HN, Pehlivanova M, Malekzadeh S. Face, content, and construct validity of a low-cost sinus surgery task trainer. *Otolaryngol Head Neck Surg* 2012;146(3):504–509
- 26 Brazil. Presidência da República. Lei No 11.794, de 8 de outubro de 2008. Regulamenta o inciso VII do § 1º do art. 225 da Constituição Federal, estabelecendo procedimentos para o uso científico de animais; revoga a Lei no 6.638, de 8 de maio de 1979; e dá outras providências. [Internet]. Brazil: 2008. http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2008/lei/l11794.htm. Accessed July 23, 2015