Sheep practice eye for ophthalmic surgery training in skills laboratory

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Pig eyes are not available for surgical practice in the Middle East and Central Asia. We reviewed the literature to select an alternative animal practice eye based on biometry, availability, expense, and the ethical issue of animal sacrifice. Twenty enucleated sheep eyes were studied with an ultrasonography immersion technique, and a variety of techniques for globe harvesting were tested and compared. The sheep eye was judged to be the best practical choice for ophthalmic surgery practice and the "bone shattering" exenteration maneuver, the most efficient harvesting method. Several anterior segment procedures were performed in the sheep eyes. Introduction of this sheep model would be instrumental in the development of ophthalmology skills laboratories and surgical training in Middle Eastern and Central Asian regions.

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Online Video

Ophthalmic surgical training aids include virtual reality simulators,[1–3] artificial eye models,[4,5] computer-based training,[6] and animal models.[7–14] Animal models are believed to be the optimal choice as they simulate live surgery well for many trainees.[15] Ophthalmic training with practice animal eyes gives the trainee the sense of touch and haptic feedback, which is experienced through tissue interaction in actual surgery and is not provided by virtual reality simulators.[16,17] Some academic centers have developed specific curricula for animal practice eyes.[18] Animal practice eyes have been instrumental in technical innovation in ophthalmic surgery.

Currently, the commonly available animal practice eye in ophthalmology skills laboratories is the pig eye. However, cultural norms in Central Asia and the Middle East restrict the nutritional use of pigs. Pig eyes are practically unavailable, and slaughtering the animal for ophthalmic training purposes is unethical and impractical. This has contributed to the underdevelopment of ophthalmology skills laboratories in these areas of the world. In this study, we describe a practice animal eye that is practical for these regions.

TECHNIQUE

Animal Eye Selection and Biometric Description

Twenty 1-year-old eyes from Afshar sheep were examined by one of the authors (S.F.M.) using immersion A-scan and B-scan ultrasound (EchoScan, US-3300) (Figure 1). Surgical and industrial rulers and calipers were used to measure equatorial and white-to-white (WTW) dimensions. The ultrasonographic and physical biometric descriptions of the sheep eyes were compared with those of other animal eyes through a literature review (Table 1). Following a qualitative analysis with the criteria of ethical acceptance of animal sacrifice, availability of the animal, expense of the eye, and biometric suitability (similarity to a human cadaver eye for the practice of anterior segment surgery), the sheep eye was selected.

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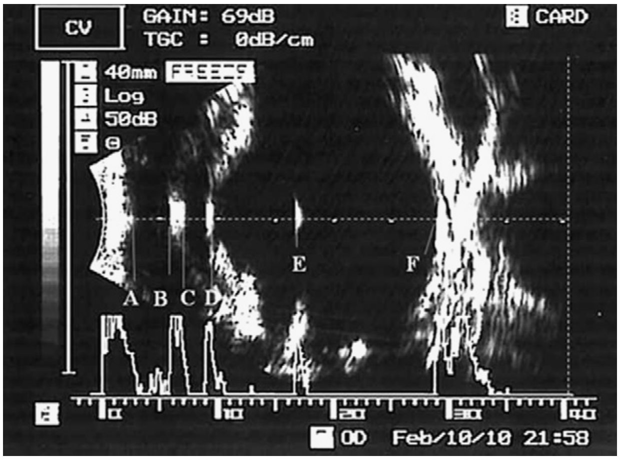

Figure 1. A and B mode ultrasonogram of a 1-year-old Afshar sheep eye. Interfaces: *A* = head of the ultrasonography probe; *B* = anterior corneal surface; *C* = posterior corneal surface; *D* = anterior lens capsule; *E* = posterior lens capsule; *F* = retina. Spaces: *A–B* = immersion liquid; *C–D* = anterior chamber; *D–E* = lens; *E–F* = vitreous cavity (ruler at the bottom in millimeters).

Animal Globe Harvest

To select the most efficient method for harvesting a large number of globes for ophthalmology skills laboratories, a variety of standard and novel methods were tested and compared in surgical trials. The subconjunctival approach and application of a globe spoon and optic nerve scissors for enucleation is an established method for human eyes; however, it requires surgical expertise and is too time consuming to be used as a conventional method for harvesting a large number of globes. Foster snare-assisted enucleation (to sever the optic nerve) was tested, but it too was time-consuming, required surgical experience, and carried a significant risk for globe damage. A soldering iron with a 500°C flame was used to burn periorbital tissue down to the periorbital rim and then into the orbit. It proved inefficient and was associated with corneal burn and edema.

Two methods were suggested by the slaughter men. A meat cleaver was used to exenterate the globe by 2 chopping hits to the periorbital bone (access through bone shattering) (Figure 2, *A*); the whole process took less than 1 minute. In the second method, the globe was removed manually (digital globe avulsion) after the periorbital tissue was cut (Figure 2, *B*). This was associated with an unwelcome complication of optic nerve avulsion and loss of globe integrity in 1 of 20 eyes in 1 of the trials (Figure 2, *C* and *D*).

Surgical Practice

Twenty sheep eyes were mounted on an artificial orbit,[19] and several anterior segment procedures were then carried out by 2 ophthalmologists (M.J. and S.F.M.) (Figure 3, *A* to *K*). The study protocol complied with the Farabi Eye Hospital Research Council's requirements. The animals were humanely killed for purposes other than this experiment, and their remains were disposed of in a standard fashion.

Results

During anterior capsulorhexis, the highly resilient lens capsule necessitated the use of a forceps (an insulin needle failed to provide sufficient control to perform the procedure) (Figure 3, *A*). Also, the large (oval-shaped) WTW diameter of the sheep cornea made a temporal-limbal incision too far for pupillary area access during phacoemulsification. An anterior clear corneal keratotomy and/or a 6 or 12 o'clock entrance was preferable.

Table 1. Biometric comparison of sheep eye with other animal eyes.

	Parameter							
Study*	AL (mm)	ED (mm)	ACD (mm)	LT (mm)	VCD (mm)	ACD/AL (mm)	VCD/AL (mm)	HWTW (mm)
Human[20,21]	24.96	24.50	2.79[22]	3.63	16.35	0.11	0.65	11.77
Sheep[†]	23.50	25.92	2.81	7.84	12.13	0.12	0.52	24.00[‡]
Pig[21]	21.07	—	2.65	7.93	10.49	0.13	0.50	—
Rabbit[20]	16.60	18.65	2.16	6.36	—	0.13	—	13.74
Goat[23,§]	22.29	—	2.93	7.85	10.95	0.13	0.50	—
Cow[24,||]	34.60	—	3.30	17.80	14.60	0.09	0.42	—

AL = axial length; ED = equatorial diameter; ACD = anterior chamber depth; LT = lens thickness; VCD = vitreous cavity diameter; HWTW = horizontal white-to-white (sizes are in millimeters)

*Mean external anterior–posterior length of the sheep globe was 25.78 (23.65, 27.10) by caliper. Axial length values of the human and pig eyes do not include corneal thickness

†Current study: Eyes of 1-year-old Afshar sheep, the commonly available slaughtered animal, were measured. Sheep eye dimensions reported by Osuobeni and Hamidzada[21] were comparable

‡The larger HWTW diameter of the sheep eye in relation to its vertical diameter (24 vs 17) gives it an oval shape. The pupil is likewise oval

§Goats were 180 days old

||Adult Holstein Friesian cows (mean age 61 months ± 22 [SD])

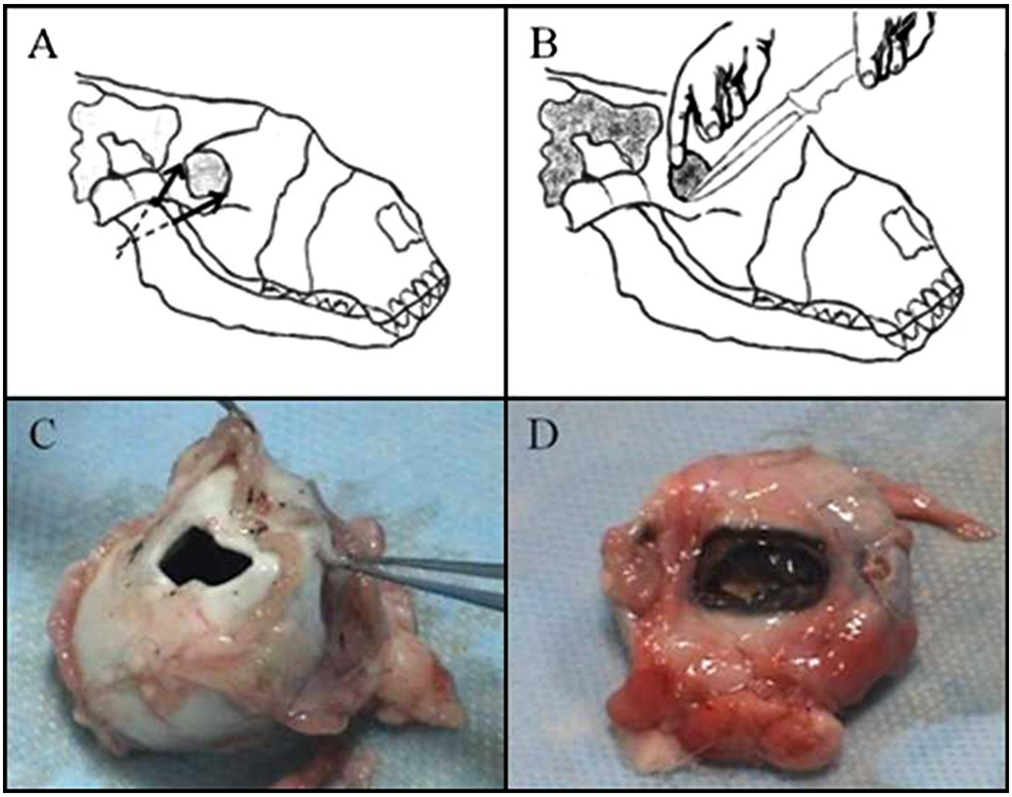

Figure 2. *A* and *B*: Approximate view of tested chopping methods for sheep globe harvest: access through bone shattering (*A*) and digital globe avulsion (*B*). *C* and *D*: Inadvertent optic nerve avulsion during globe harvest (*C*) and lost integrity of the globe (*D*).

The anterior chamber was also relatively unstable during phacoemulsification. As shown in Table 1, the sheep eye lens is thick and to emulsify the deeper portions, the handpiece must be held vertically, similar to the position during phacoemulsification in highly myopic or vitrectomized eyes (Figure 3, *B*). The lens is so voluminous that complete removal may not be feasible given the comparatively small size of the phaco handpiece tip. This runs the risk of zonular dialysis. During lamellar keratoplasty using the big-bubble technique, the pattern of interstitial air visible inside the sheep corneal stroma after air injection was different from the pattern in the human cornea; a lattice-like pattern in the sheep cornea versus a ground-glass appearance in the human cornea (Figure 3, *G*). During insertion of an iris-fixated phakic intraocular lens, the iris proved to be too leathery for easy enclavation (Figure 3, *J*). The bulky third eyelid of the sheep eye sometimes intruded in the surgical field (Figure 3, *L*). The video (available at http://jcrsjournal.org) shows harvesting methods and sample anterior segment procedures in sheep practice eyes.

DISCUSSION

In contrast to the routine use of pig globes as practice eyes around the world, sheep eyes have rarely been used in ophthalmic surgery training.[7] We identified the sheep eye as the most practical choice and the best substitute for this purpose in the Middle East and Central Asia. (The cost of each sheep globe after exenteration by the slaughter men was about 1.50 USD at the time of the surgical trials.) Sheep and cows are the main red meat sources in the region. However, the cow eye, despite being available, is quite different from the human eye biometrically, excluding its use for training purposes.[24]

An efficient animal model for surgical practice requires a reliable supply of practice eyes, and this requires an efficient method of globe harvesting. We tested various standard and novel methods and concluded that the standard human eye enucleation methods are time consuming and require special skills. In contrast, exenteration methods used by slaughter men are speedy, economical, and simpler. It should be noted that these methods require adroit hands, which slaughter men have. In exenteration, the removed globe is accompanied by the soft tissue, which can act as sealers when the globe is placed on a globe fixation system.[19]

Surgical competence is now mandated by the American Board of Ophthalmology, and surgical proficiency has been added to the 6 competencies advocated by the Accreditation Council for Graduate

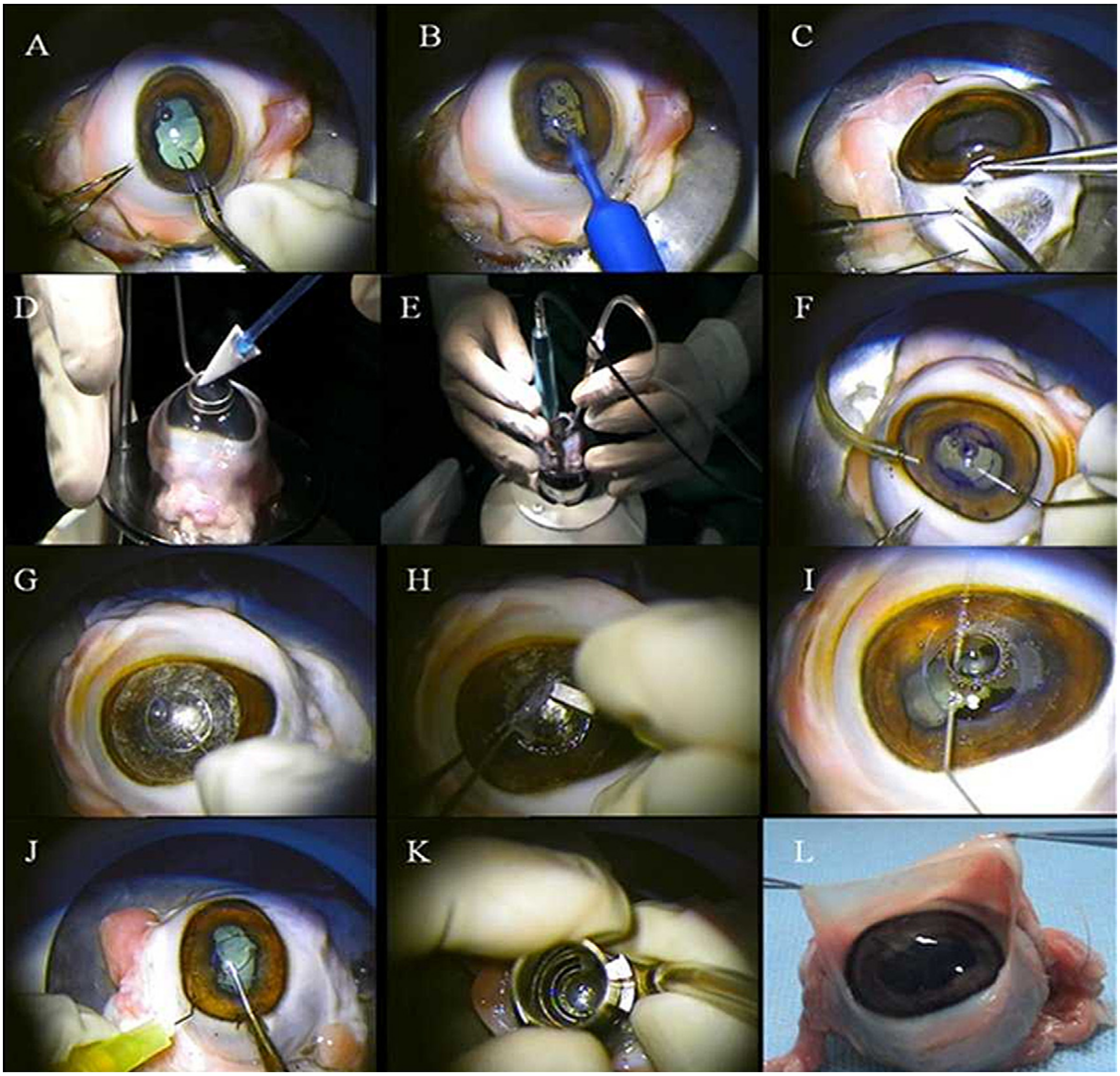

Figure 3. Preliminary surgical experience and observations during the practice of anterior segment procedures in sheep eyes mounted on the globe fixation system. *A*: Anterior capsulorhexis. *B*: Phacoemulsification. *C*: Partial-thickness scleral dissection and trabeculectomy. *D*: Alcohol-assisted epithelial debridement as the initial step in photorefractive keratectomy. *E*: Microkeratome pass to create a corneal flap for laser in-situ keratomileusis. *F*: Descemetorhexis stage of posterior lamellar keratoplasty. *G*: Use of the big-bubble technique for lamellar keratoplasty. *H* and *I*: Total anterior lamellar keratoplasty and the bare Descemet membrane. *J*: Enclavation of iris-fixated phakic intraocular lens. *K*: Intracorneal ring segment implantation. *L*: The bulky third eyelid of the sheep eye.

Medical Education.[25] Acquisition of surgical skills is stressful for the trainee and burdensome for the trainer. It reduces operating room efficiency and affects patient comfort. More important, a beginning surgeon operating on a real case (a sighted eye in ophthalmology) has ethical implications and it becomes even more problematic when there is a long learning curve; for instance, it has been shown that acceptable surgical competence is achieved after 80 cases for phacoemulsification[26] and skill continues to improve in the early years of practice. Thus, training models play an indispensable role in facilitating ophthalmic surgical skill acquisition. They not only streamline learning and teaching, but also address the ethical dilemma.[15]

In our surgical trials, the sheep model showed varied efficacy in different procedures. Its applicability to posterior segment procedures must also be tested. No training model fully simulates the human eye experience. For instance, the lens nucleus of animal eyes are quite different from the human cataractous lens in terms of firmness and size.[7] Some investigators have applied novel methods to enhance the surgical experience; eg, formalin[8] and alcohol[9] used to induce cataract in situ and insertion of human cataractous nucleus or chestnuts[10] into the anterior chamber of animal eyes for emulsification.[7,14] These models may not simulate real case experience, but they are indispensable for developing hand motor coordination in terms of microscope control, foot-pedal control, handling the hand piece, developing bimanual dexterity, and acquiring basic surgical steps such as nucleus sculpting and cracking.[10]

In summary, we propose the sheep eye as a training model and have provided a comparative biometric profile and identified an efficient harvesting method. Further assessment of the educational value of this system for residency and fellowship training is recommended.

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