

## Spine Surgery in a Large Animal Model: Experiences and Limitations

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**INTRODUCTION:** Sheep have become a convenient, economical and practical large animal model for orthopaedic research. For spine surgery, they are useful for investigating fusion devices, growth factors and their carriers, instrumentation methods, vertebroplasty-kyphoplasty methods, disc replacement and vertebral body corpectomy [1].

**VENTRAL “ANTERIOR” LUMBAR INTERBODY FUSION (ALIF):** In the breed we use, there are usually 7 sometimes 6, lumbar vertebrae. Using a left retroperitoneal approach, up to four lumbar discs can be readily accessed. Commonly, two fusion sites are used with a normal space in between. Cylindrical metal or ceramic cages (with or without growth factors and their carriers) can be evaluated [1]. If the interbody fusion site is unstable, unilateral instrumentation using pedicle screws will provide stability to the construct.

**DORSAL “POSTERIOR” LUMBAR INTERBODY FUSION (PLIF)** Using a dorsal approach, access to 3 or 4 levels are possible. Pedicle-screw instrumentation spanning several levels is possible. Access to the disc space using this approach is difficult.

**TRANSVERSE LUMBAR INTERBODY FUSION (TLIF):** Using a dorsal approach, single-level fusion by decortication of the transverse processes (with or without instrumentation) is used to compare bone-graft substitutes and growth factors and their carriers to autograft [2].

**CERVICAL INTERBODY FUSION:** With the sheep in dorsal recumbency, one or two fusion sites are preferred. Tri-cortical autograft or cancellous bone is available from the sternum, and avoids having to reposition the sheep following procurement from the iliac crest. Graft-containment implants can be evaluated [3] as well as interbody fusion devices or disc replacements. The cervical disc space is cup-shaped and smaller than the disc space of the lumbar region.

**VERTEBROPLASTY:** Three or 4 vertebral bodies can be drilled from the lateral side, cavitated and used to test bone-void fillers [1]. The vertebral body of sheep is too dense to drill a small hole in the outer cortical shell and inject a bone void filler under pressure or using

kyphoplasty. CT scans are more useful than plain radiographs to document the extent of filling and monitor behavior of the filler over time. Mechanical testing of individual vertebral bodies and histology of surrounding bone, epaxial musculature and adjacent spinal cord, are useful endpoints.

**LUMBAR CORPECTOMY:** Removal of one vertebral body and replacement with an implant can be used to evaluate construct design, bone graft substitutes, and growth factors that are used to fill the prosthesis. Unilateral instrumentation using two pedicle screws in each vertebral body is essential for stability.

**LIMITATIONS OF THIS MODEL:** The shape and dimensions of quadrupedal vertebrae are very different than humans and implants and devices have to be adapted. Sheep vertebral body bone density is much higher than in elderly people which may limit some studies, although osteoporosis of the spine can be achieved in 6 months following ovariectomy and a dietary-induced metabolic acidosis [7]. Fusion of vertebral bodies in animals can be more rapid than in people so evaluation at early endpoints (6 mo. or less) is recommended in spine fusion studies. Skeletally mature (> 3.5 yrs. old) sheep are used in most studies except where growth disturbances such as scoliosis are being studied.

**REFERENCES:** <sup>1</sup>A.S. Turner (2001) *Research in Orthopaedic Surgery*, Academic Press, pages 80-1 to 80-64. <sup>2</sup>J.A. Marini, M.E. Kovach, A.S. Turner, *et al.* Biomechanical evaluation of a combined osteoconductive and osteoinductive bone graft material for spine fusion. *Proc 51<sup>st</sup> Orthop Res Soc*, Washington, DC (Abstr.) p. 689, 2005. <sup>3</sup>G.B. Cornwall, C.P. Ames, N.R. Crawford, *et al.* *In-vivo* evaluation of bioresorbable polylactide implants for cervical graft containment in an ovine spinal fusion model. *J. Neurosurg: Neurosurgical Focus* **16(3)**: Article #5, 2004. <sup>4</sup>J.M. MacLeay, J.D. Olson, R.M. Enns, *et al.* Dietary induced metabolic acidosis decreases bone mineral density in mature ovariectomized ewes. *Calcified Tiss. Int.* **75**:431-437, 2005.