Key Points

- Fracture fixation, but not general orthopedic surgery, presents a greater risk for complications for anesthetic recovery
- A variety of systems, each with their own advantages and disadvantages, are available for assisted recoveries
- Expertise with a single system may be the most important factor determining the success rate of different recovery systems

Beyond the challenges equine surgeons are faced with regarding successful surgical repair of fractures and other orthopedic conditions are those associated with aiding the horse to recover from general anesthesia without major complication. As such, a variety of systems have been developed to aid horses through the recovery process. General anesthesia carries a considerable risk to even systemically healthy patients; a large-scale, multicenter study, “The Confidential Enquiry into Perioperative Equine Fatalities (CEPEF)” (Johnston GM 2002), reports the death rate of horses undergoing ‘non-colic’ surgery to be 0.9%, or 1 in 111 patients. Horses undergoing elective orthopedic procedures are typically systemically stable and general anesthesia is relatively short, while those presenting for major procedures such as fracture fixation and arthrodesis are frequently stressed, painful, exhausted, and subjected to being under anesthesia for long periods of time. The CEPEF reports that the mortality rate for horses undergoing general orthopedic surgery is equivalent to the overall rate, at 0.8%. Horses undergoing fracture repair suffered a mortality rate of 5%. The overall rate of fracture upon recovery was 0.2%, or 2/1000 cases. Observation of these data delineate three important points; 1) to show the general risk of anesthetic recovery to the musculoskeletal system, 2) to highlight the increased risk for patients suffering major orthopedic disease, and 3) to establish an inclusive and unbiased rate of mortality to which individual systems of recovery can be compared and evaluated.

Systems for anesthetic recovery include both the physical and pharmacologic methods utilized to assist or modify the event. The vast majority of recoveries occur in padded stalls, with and without the use of a deep mattress. A variety of compressible floor surfaces are available to help provide both comfort and traction, and to minimize the forces placed on the musculoskeletal system while the horse is attempting to stand. Communication with a number of academic and private equine hospitals reveals that by far, most operations use padded stalls with head and tail ropes to perform hand assisted recoveries on their equine orthopedic patients. The largest and most recent study evaluating perioperative fatalities associated with general anesthesia at a private practice using a head and tail assisted recovery system reports a general mortality rate of 0.12% (21 out of 17,961 cases) (Bidwell LA 2007). Stratification of this data reveals a mortality rate of 0.05% in general orthopedic cases, and 0.5% in cases of fracture/arthrodesis. Of 8 cases that fractured on recovery (0.04%), none occurred in horses undergoing major orthopedic procedures.
The use of a sling has been described to reduce the risk of injury in patients recovering from musculoskeletal surgery (Taylor 2005). This technique requires more personnel, expertise, specialized equipment, and benefits from a tailored anesthetic protocol. Full body slings, such as the Anderson sling, are available in most academic institutions and a number of large private referral practices as well. A much smaller number of cases were evaluated in this retrospective (n=32), though 15 of these included major orthopedic procedures (fracture/arthrodesis), and 9 general orthopedic procedures. No complications or deaths were reported in any of these cases secondary to recovery in an Anderson sling. Successful use of the sling requires precise positioning of the horse and fitting of the device, which is a skill obtained through experience. Sling recovery quality is also improved with a specific anesthetic protocol, including the use of a rapidly eliminated inhalant anesthetic (Desflurane) for maintenance, and transitioning to a CRI of an injectable anesthetic (propofol) for the recovery period.

A rapidly inflating-deflating air pillow was developed to provide cushioning to the musculoskeletal system, and to prolong lateral recumbency until the horse has regained enough coordination and strength to stand safely and successfully (Ray-Miller 2006). In this study, types of surgical procedures were not reported, so rates specific to orthopedic cases cannot be determined. Horses recovered on the air-inflated pillow were able to stand after significantly fewer attempts than horses recovering on just a padded floor. No fatalities or fractures were encountered subsequent to recovery, but 20% of cases sustained minor injuries.

Few hospitals are equipped with hydraulic tilt tables, though they have been described to successfully aid anesthetic recovery in horses (Elmas 2007). The table facilitates transition from lateral recumbency to standing, and also forcibly maintains the animal in a non-weight bearing position until the effects of the anesthetics have worn off sufficiently. Failure to adapt to the table occurred in 6/54 horses, and 3 of these resulted in catastrophic failure of a fracture repair when a conventional recovery stall was used instead. One single horse suffered a catastrophic failure during recovery on the table. Adequate padding between the animal and the steel table and its frame is difficult to achieve, and may result in skin abrasions over contact points, and myositis. Tilt table recovery is more labor intensive than hand assisted stall recoveries, requires specialized equipment, and may prolong recovery times as compared with other methods. No specific anesthetic protocols have been described as producing superior results when used in conjunction with this technique.

A small number of equine hospitals have systems to recover patients in water. The first is a hydro-pool system, in which the horse is lifted into a pool with a sling, and then the pool floor is raised to ground level as the horse becomes coordinated enough to stand. 60 cases were evaluated retrospectively, 20 of which underwent arthroscopy/arthrotomy, and 24 of which underwent fracture repair or arthrodesis (Tidwell 2002). 10 horses suffered from pulmonary edema with one fatality, and an additional three developed a surgical site infection, possibly due to contamination in the water. One institution offers a pool-raft recovery system, in which the horse never comes into contact with the water as it is positioned in an inflatable raft, thereby avoiding the pulmonary effects associated with submersion. Once able to stand, the animal is transported to a conventional recovery stall, via a sling. 471 recoveries were reviewed; data revealed a mortality rate of 2%, and a complication rate of 7% in the pool, and 13% in the recovery stall following extraction from the pool (Sullivan 2002). Causes of death included failure of fixation and/or pulmonary dysfunction. Almost all cases evaluated had undergone major orthopedic surgery (fracture fixation, arthrodesis). Pool recoveries in general require very
expensive equipment that needs constant maintenance, and are very labor intensive. Recovery times may be prolonged, and personnel need to be well trained in the procedure.

The final factor worth consideration in evaluating anesthetic recovery in horses is the type of maintenance anesthesia used. Sevoflurane is associated with shorter and better recoveries than is isoflurane. Total intravenous anesthesia has been limited to short procedures in the past, which excludes their use during major orthopedic surgery. Incorporation of constant rate infusions of injectable anesthetics with inhalation anesthetics decreases the dose of volatile gas necessary, and may help to produce more controlled recoveries. The CEPEF investigation showed that total intravenous anesthesia was associated with a significantly reduced risk of dying (0.3%) as compared with total inhalational anesthesia (2.9%, not including combination techniques of IV induction and inhalant maintenance). While these numbers are provocative, no other clinical studies on orthopedic patients have been performed to critically evaluate these techniques.

When comparing the data from the large scale study and the individual studies performed on individual recovery systems, an observer must take into account two major things; 1) the number of cases evaluated in each study, and 2) the types of cases evaluated in order to understand the relative risk for failure of each population. Table 1 summarizes mortality and complication rates observed in the retrospective data discussed. Above all, the most influential factor that determines success for each individual technique may simply be the expertise of the people involved in the recovery process. Seemingly, the least complicated method of recovery (head and tail ropes) successfully achieved the lowest mortality rate in major orthopedic procedures when observed in a large population. This is likely owing to the significant experience that personnel gain from recovering such a large number of animals. The availability of equine slings along with the low rate of complication observed in the retrospective study suggests that it may be a useful alternative for surgeons considering methods of recovery following orthopedic repair.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>N =</th>
<th>Mortality Rate (overall)</th>
<th>Mortality: Gen. Ortho</th>
<th>Mortality: Arthrodesis</th>
<th>Fx/Arthrodesis: Fx sustained on recovery</th>
<th>Complication rate (non-fatal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEPEF (Johnston 2002)</td>
<td>35,978 (non-colic)</td>
<td>0.9%</td>
<td>0.8%</td>
<td>5%</td>
<td>0.2%</td>
<td>NR</td>
</tr>
<tr>
<td>Head and tail ropes (Bidwell 2007)</td>
<td>17,961 (5727 ortho)</td>
<td>0.12%</td>
<td>0.05%</td>
<td>0.5%</td>
<td>0.04%</td>
<td>NR</td>
</tr>
<tr>
<td>Anderson sling (Taylor 2005)</td>
<td>32 (ortho + misc)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Inflating-deflating pillow (Ray-Miller 2006)</td>
<td>148 (all types cases)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20%</td>
</tr>
<tr>
<td>Tilt table (Elmas 2007)</td>
<td>54 (all major ortho)</td>
<td>1/54 (1.9%)</td>
<td>(4/54, 7.4%*)</td>
<td>NR</td>
<td>1/54 (4/54*)</td>
<td>8/54 (15%)</td>
</tr>
<tr>
<td>Hydro-pool (Tidwell 2002)</td>
<td>60 (44 ortho)</td>
<td>1/60 (1.7%)</td>
<td>NR</td>
<td>NR</td>
<td>0</td>
<td>18/60 (30%)</td>
</tr>
<tr>
<td>Pool-Raft (Sullivan 2002)</td>
<td>471 (major ortho)</td>
<td>2%</td>
<td>NR</td>
<td>2%</td>
<td>2% (failure of fixation)</td>
<td>7% (pool), 13% (stall)</td>
</tr>
</tbody>
</table>

NR = Not reported

*includes horses that failed to recover on the tilt table and were recovered conventionally
• Ray-Miller WM, Hodgson DS, McMurphy RM, et al. Comparison of recoveries from anesthesia of horses placed on a rapidly inflating-deflating air pillow or the floor of a padded stall. JAVMA 229:711-716