Artykuł przeglądowy *Review*

Equine surgery: Effectiveness of procedures, risk of complications, and the importance of perioperative care

IZABELA GAZDA[1], JAN KITA[1], BEATA KACZMAREK[2], KINGA BASIŃSKA[3], PAWEŁ DZIURA[1], IWONA JANCZAREK[1]

[1]Department of Horse Breeding and Use, University of Life Sciences in Lublin, Akademicka 13, 20-950 Lublin, Poland
[2]Department and Clinic of Animal Internal Diseases, Faculty of Veterinary Medicine, University of Life Sciences in Lublin, Akademicka 13, 20-950 Lublin, Poland
[3]Department of Genetics, Animal Breeding and Ethology, Faculty of Animal Science, University of Agriculture in Cracow, 30-059 Cracow, Poland

Received 27.04.2026 *Accepted 01.06.2026*

Gazda I., Kita J., Kaczmarek B., Basińska K., Dziura P., Janczarek I.

Modern equine surgery: Effectiveness of procedures, risk of complications, and the importance of perioperative care

Summary

Equine veterinary surgery plays a pivotal role in the treatment of numerous conditions. The aim of this review was to analyze the current state of knowledge regarding selected surgical procedures, the risk of complications, and the importance of perioperative care. A wide range of techniques are currently available for an individualized approach to each case. Despite high survival rates, however, surgical procedures are still associated with a significant risk of complications. The use of general anesthesia, the course of the recovery phase, and the prevention of postoperative infections remain particularly challenging. Therefore, this field continues to pose a substantial clinical challenge, requiring further research and optimization of diagnostic and therapeutic procedures.

Keywords: horse, veterinary medicine, surgery, postoperative complications

Surgical procedures play an important role in the treatment of numerous diseases and functional disorders (48). In severe cases, surgery may be the only option to avoid euthanasia. Equine veterinary surgery represents one of the most demanding and complex areas of veterinary medicine (13, 61, 85). The anatomical structure of horses makes access to their abdominal cavity difficult, and the use of general anesthesia is associated with a risk of complications that may even result in death. The selection of an appropriate method is often not standardized but rather based on a thorough analysis of the individual characteristics of each case (86).

Equine surgical practice is continuously evolving toward reduced invasiveness, thereby minimizing the risk of complications and enabling a faster recovery of the animal (86). Currently, a wide range of methods are available, allowing procedures to be tailored both to the specific case and to the conditions under which the surgery is performed (41). Furthermore, studies focusing on perioperative pain assessment are emerging, including the development of scales that facilitate rapid recognition and implementation of appropriate treatment (65). The aim of this paper is to present the current state of knowledge on equine veterinary surgery, with particular emphasis on the most commonly performed procedures, along with an analysis of factors affecting patient survival and the role of operating room organization.

Horse's operating positions during surgery

Surgical procedures in horses can be performed in dorsal recumbency, lateral recumbency, or in the standing position (31, 79, 80). In dorsal recumbency, the surgeon has improved access to the abdominal cavity, allowing for a more precise assessment of intra-abdominal structures (80). Additionally, in complex cases, the position of the mare can be adjusted using a hoist. However, this approach requires the use of general anesthesia. Lateral recumbency is used particu-

larly in laparoscopic castration procedures (31), as it reduces pressure on the thorax while maintaining good visualization of pelvic structures. Standing procedures, on the other hand, can be performed without general anesthesia (79) but are not suitable for more complex cases and carry a risk of collapse or sudden movement.

One of the most commonly performed surgical procedures in cases of severe abdominal pathology is midline laparotomy in dorsal recumbency – classical laparotomy (78, 90). This is a highly invasive procedure performed under general anesthesia, involving both visceral and somatic structures. The abdominal cavity is opened with an incision along the linea alba, providing access to internal organs. A variation of classical laparotomy is flank laparotomy, performed in the standing position (79). This technique involves a small incision in the flank region, cutting through the skin and fascia, followed by separation of muscle layers along their fibers. It is increasingly used because of its high effectiveness and the absence of risks associated with recovery from general anesthesia. However, due to the nature of the procedure, it is highly susceptible to environmental influences and sudden movements of the horse. Therefore, it should not be used in more severe cases or in excitable animals.

Moreover, attention should also be paid to the safety of the veterinarian performing the procedure (87). More than 90% of personnel experience at least one injury during their career. According to the authors, most injuries involve kicks to the lower limbs or head, being stepped on, or bites. These incidents most commonly occurred during examination or treatment of the distal parts of the limbs. Similar findings were reported by Parkin et al. (74), who indicated that an equine veterinary surgeon may sustain between 7 and 9 injuries over the course of their career. Most cases are caused by kicks from the hind limb, which result in contusions, fractures, or wounds. Slightly less than 40% of injuries among the surveyed individuals occurred during sedation of the horse, and approximately 30% occurred when another method of restraint was used. Therefore, the development of appropriate safety procedures, staff education, and the use of protective equipment, such as helmets, are of major importance (87).

Anesthesiology and perioperative care

General anaesthesia. One of the main factors influencing the success of surgical procedures is the risk associated with general anesthesia (56, 59). In horses, respiratory depression and alveolar hypoventilation frequently occur, leading to hypercapnia, hypoxemia, and subsequently respiratory acidosis (59). Additionally, dorsal recumbency results in reduced respiratory efficiency due to the anatomical structure of horses. Consequently, the risk of complications and mortality is significantly higher compared to that in other species (35, 59). Nevertheless, general anesthesia allows for effective nociceptive blockade, thereby playing a crucial role in many surgical procedures (23, 37).

Pain is a symptom associated with both physical and psychological disturbances (1, 6). Its high intensity during surgical procedures may lead to a range of adverse consequences (1). If the animal is not adequately anesthetized, it is exposed to stress and increased pain perception during the procedure, as well as prolonged recovery and potential behavioral disturbances. These factors not only reduce animal welfare, but also pose a risk to the safety of both the surgeon and the patient, as the animal becomes more reactive to surgical stimuli.

Pain assessment can be performed using both unidimensional and multidimensional scales (6). Unidimensional scales assess only a single aspect of pain, making them simple and quick to apply. In human medicine, such scales are widely used in clinical settings and are typically based on pain intensity (54), with examples including the Faces Pain Scale, Numeric Rating Scale, and Visual Analog Scale. However, in veterinary medicine, unidimensional scales have a significant limitation due to high inter-observer variability (6). Multidimensional scales provide more reliable clinical assessments based on various types of parameters (66). However, they do not provide a fully objective assessment and may require longer observation periods to detect more subtle signs of pain. Therefore, the assessment of postoperative pain in horses remains particularly challenging due to the limited availability of fully validated clinical tools.

The cooperation between the anesthesiologist and the surgeon plays a pivotal role in patient assessment, enabling immediate and effective response in the event of complications or the need to adjust the level of anesthesia (23). The primary parameters monitored simultaneously during surgery include pulse, heart rate, and respiratory rate (24, 59). The correlation of these parameters allows for an initial assessment of circulatory disturbances, arrhythmias, or other abnormalities. A more objective clinical and field-based evaluation may also be achieved through monitoring blood pressure, capillary refill time, respiratory rate and quality, levels of blood gases and anesthetic agents, as well as changes in eye position (24). These parameters may prove essential for a more accurate assessment of the animal's condition.

Anesthesia can be classified into intravenous (injectable) and inhalation types (23). Intravenous anesthesia, involving administration of anesthetic agents by injection, is the most commonly used method. Inhalation anesthesia is less widely available and involves delivering anesthetic agents through specialized anesthetic equipment, requiring precise monitoring that is typically only feasible under clinical conditions (37). Regardless of the type of anesthesia, the risk is significantly lower when procedures are performed in hospital settings (23). Higher success rates are also

achieved in elective procedures (35, 37). The risk of death is several times as high in emergency surgeries, particularly in cases of colic and fractures. Additional risk factors include poor general health status, very young or advanced age, dorsal recumbency, prolonged duration of anesthesia, and fatigue of the surgical team. The primary causes of mortality include cardiac arrest, injuries sustained during recovery, myopathies, neuropathies, and post-anesthetic respiratory failure. However, with the development of modern anesthetic techniques, complications are increasingly limited mainly to fractures occurring during the recovery phase.

Despite significant advances in veterinary anesthesiology and analgesia, the rate of complications and mortality remains high, with the majority of adverse events being associated with the recovery phase (35, 37). The most commonly reported complications during this stage are mechanical injuries, such as limb fractures, which are often associated with permanent loss of athletic function or the need for euthanasia (15). According to data collected by Dugdale et al. (28), as many as 71.4% of deaths were related to fractures or dislocations of the limbs. Similar findings were reported by Johnston et al. (56). This is one of the reasons why veterinarians are increasingly opting to perform procedures in the standing horse (9).

Sling systems appear to be a suitable alternative for horses at increased risk of injury. Recently, a specialized air-cushion system has also been developed, in which the horse is maintained in a semi-standing position, thereby avoiding the transition from lateral recumbency to standing (88). Studies have indicated that this method may provide a safer and calmer recovery. However, further research is required, as potential challenges may arise related to logistical requirements, difficulties in application in smaller horses, and the risk of improper positioning within the system. Postoperative care following surgical procedures requires both appropriate technical facilities and the presence of experienced personnel (5).

Sedation and local anaesthesia. The use of local anesthesia combined with sedation is considered an alternative approach (43). In this case, the anesthetic agent interacts with neuronal membranes, blocking sodium channels. This results in interruption of nociceptive signal transmission to the spinal cord and brain, leading to temporary loss of pain sensation in a specific area of the body. This method does not require the horse to be placed in recumbency, thereby avoiding complications associated with general anesthesia and procedures performed in a lying position, and reducing the incidence of complications related to recovery and standing.

Epidural anaesthesia. A specific type of local anesthesia is epidural anesthesia (45), which involves administration of anesthetic agents into the epidural space to block sensory and motor spinal nerve roots. It is most commonly used in the treatment of orthopedic conditions, particularly affecting the hind limbs (tearing of the perineum etc.) (26). Reported complications are typically transient and include excitation, pruritus, and decreased fecal output. Colic, ataxia, and urinary retention have also been observed relatively frequently.

Numerous methods are employed to prevent complications associated with recovery following surgery performed in recumbency (15). During this process, the animal should remain under continuous observation. To improve safety and comfort, various assisted recovery techniques have been developed. The most commonly used method involves ropes attached to the head and tail (36). Other approaches include sling systems, water-based recovery pools, and air-cushion support systems. Each of these methods has its own advantages and limitations, so the choice should be tailored to the individual characteristics of each case.

Recovery in specially padded stalls or with the use of head and tail ropes has been shown to be effective in restoring consciousness in horses, although it does not completely eliminate the risk of fractures (36). These methods, however, are widely available in veterinary clinics. Water-based recovery systems are characterized by a high level of safety in terms of preventing trauma associated with recovery. On the other hand, their use may be associated with pulmonary edema due to increased extrathoracic hydrostatic pressure resulting from water immersion. Additional limitations include wound contamination, the need for specialized personnel, and time-consuming procedures.

Most commonly performed procedures

Gynecological surgeries. One condition requiring surgical intervention is uterine torsion (18). This disorder is a classical maternal complication of pregnancy, most commonly occurring between the 8th and 11th month of gestation. The primary clinical sign is abdominal pain of varying severity (90), often accompanied by restlessness, anorexia, premature sweating, and frequent urination. Additional signs may include decreased fetal movement observed in the flank region and premature lactation. In pregnancies not exceeding 320 days, flank laparotomy on the side of the torsion is typically performed. This method increases the chances of carrying the pregnancy to term and delivering a live foal, and it can also be performed under field conditions (79, 80). In cases where pathological changes are present, classical laparotomy is recommended for precise evaluation of abdominal organs (80). According to Samsel (79), severe pathological changes are associated mainly with torsions exceeding 180°. Failure to intervene may result in serious complications, including death of both the mare and the fetus (79, 80). Therefore, careful monitoring is essential to assess the health status of the mare.

Particularly important among procedures involving mares is cesarean section (2, 76). One of the indica-

tions for cesarean section is, for example, transverse fetal presentation. Indications for the procedure may be classified as relative or absolute. Relative indications refer to situations where alternative techniques may still be attempted, whereas absolute indications imply that surgical intervention is the only viable solution. Another classification distinguishes between emergency and elective procedures, with higher foal survival rates being reported in the latter. Regardless of classification, the most commonly used technique is midline laparotomy via an incision along the linea alba. A flank incision is used when the procedure must be performed in the standing position.

The risk of complications and foal survival rates during cesarean section depend primarily on the mare's age, the timing of intervention, and the correctness of the procedure (2, 76). Statistically, at least one postoperative complication was reported in approximately 65% of mares, mainly in more complex procedures lasting longer than 1.5 hours. Foal survival rates were higher in younger mares. Outcomes also improved with shorter intervals between the onset of dystocia and surgical intervention, as well as with greater experience of the attending veterinarian. On the other hand, in cases where fetal death is confirmed, partial fetotomy is often performed (76). If vaginal edema is minimal, the cervix is dilated, and the fetus is non-viable, this method is considered a safe approach for resolving dystocia (2). However, failure of the procedure may necessitate cesarean section and, in extreme cases, may result in the death of the mare.

Castration. In stallions, the most commonly performed surgical procedure is castration (31). Currently, numerous techniques and their modifications are available. Traditional castration may be performed using an open, closed, or semi-closed technique (57). Under field conditions, closed or semi-closed castration in the standing horse is most commonly performed, with complication rates of approximately 6.1% and 23.4%, respectively. The choice of method ultimately depends on the surgeon's experience, the age and condition of the stallion, and the conditions under which the procedure is performed. This is particularly important because, despite low mortality rates, postoperative complications may occur in 10-23% of cases (49, 57, 75). The most commonly reported complications include excessive swelling, followed by infection and stiff gait. Less frequently reported complications include funiculitis, eventration, and intra-scrotal or intra-vaginal hemorrhage. In some cases, surgery may lead to long-term consequences (25). After castration, locomotor abnormalities and behavioral disorders may occur, including irritability, aggression, reluctance to work, as well as back and croup pain. These signs may result from abnormal postoperative adhesions, chronic inflammation, or painful neuromas. One of the rarer late complications is staphylococcal granuloma of the spermatic cord stump (38). This condition is often associated with infection of the postoperative wound and, in advanced cases, may require surgical treatment.

Another technique used for castration is laparoscopy, which is characterized by minimal invasiveness and a low risk of complications (31, 68). However, this technique is associated with high costs, the need for specialized equipment, and the requirement for substantial surgical experience. The procedure involves the introduction of a camera and surgical instruments into the abdominal cavity (31). It may be performed using either clipping techniques or bipolar coagulation. Advantages of the clipping method include precise ligation of the testicular vessels and transection of the spermatic cord without the need for extensive tissue dissection. In contrast, bipolar coagulation may present technical limitations when sealing larger testicular vessels. Additionally, visualization of the operated structures may be temporarily restricted.

Joint surgery. Joint disorders of equine limbs often require surgical treatment (71). The primary indication is osteochondrosis, a disease affecting cartilage and the subchondral bone layer, particularly in young racehorses. It may lead to the separation of pathological osteochondral fragments and the development of aseptic osteochondral necrosis. The most commonly used surgical treatment in such cases is arthroscopy, which is also employed for the diagnosis and intra-articular treatment of conditions such as small bone fragment fractures (33). The procedure involves insertion of an arthroscope into the joint and manipulation of surgical instruments to enable diagnosis or removal of lesions.

Another commonly performed surgical procedure involving limb joints is arthrodesis (19). This procedure consists in a surgical fusion of a joint, with the aim of enabling the animal to move without pain. It is particularly indicated in cases of degenerative disease of the fetlock joint. This condition arises as a result of mechanical trauma or developmental abnormalities, leading to impaired joint function (11). Arthrodesis in this clinical context shows a favorable prognosis, with survival rates of up to 90% (84). It is also noteworthy that approximately 65% of horses were able to return fully to their intended use. Similar findings were reported by Herthel et al. (46), who demonstrated that higher success rates were associated with arthrodesis of the hind limbs (73% of cases) compared to the forelimbs (25% of cases). Postoperative complications of arthrodesis were primarily mild (19), while more severe complications, such as fever or pronounced lameness, were less frequent and typically resolved before discharge. Comparable findings regarding complications were also reported by de Souza et al. (84), who highlighted a relatively low incidence, with surgical site infections occurring in only 12% of cases.

Other surgical procedures are also performed within the limbs, including those involving the tendinous apparatus and the skeletal system. One example is tenoscopy, a minimally invasive procedure involving

the introduction of a camera into the tendon sheath to diagnose pathological changes, with the possibility of immediate treatment, such as tendon debridement (16). Another procedure performed within the tendinous apparatus is tenotomy, which involves transection of tendons, most commonly the digital flexor tendons (51). This procedure is performed mainly in cases of flexural deformities and pathological conditions of the digital flexor tendons. In milder cases, desmotomy may be performed, involving transection of the accessory ligament of the digital flexor tendon.

Limb fractures are particularly problematic in horses (60) – especially in cases of fractures of large long bones, such as the femur, where conservative immobilization with a bandage or cast is insufficient. In such cases, the veterinarian often decides to perform osteosynthesis, that is, stabilization of bone fragments with implants. In contrast, osteotomy is used to correct bone deformities, particularly multiplanar deformities or those involving the bone shaft (82). This procedure involves precise cutting of the bone, which is then repositioned in such a way as to correct the deformity.

Surgical procedures involving the head region. A commonly performed procedure in equine dentistry is tooth extraction, mainly involving premolars and molars (63). It is performed, among other indications, in cases of chronic apical infections, crown fractures, or extensive tooth damage. Due to the close anatomical relationship, extraction of maxillary teeth may lead to sinus complications. Jehle et al. (55) report that in 56% of cases it was necessary to directly access the sinuses and remove pathological lesions by techniques such as trephination or SENMAP.

Laryngeal procedures are performed primarily in cases of upper airway disorders affecting respiratory efficiency and performance (40). One such condition is weakness or paralysis of the recurrent laryngeal nerve. Treatment depends on the severity of the disease. In more advanced cases, laryngoplasty should be performed, with the aim of permanently abducting the arytenoid cartilage and improving airflow (14, 40). Another respiratory disorder requiring surgical intervention is iDDSP, that is, intermittent dorsal displacement of the soft palate (62). This condition involves periodic displacement of the soft palate above the epiglottis during exercise, resulting in breathing difficulties and reduced performance. The most commonly performed procedure in such cases is laryngohyoid tie-forward (LTF), which aims to stabilize the larynx. As a result, the larynx becomes less susceptible to recurrence of the disorder.

It is also important to mention surgical procedures performed in the treatment of ophthalmic diseases (12). Advances in the understanding and development of microsurgical techniques have made it possible to perform complex procedures involving the globe and orbital region, as well as to effectively treat glaucoma. Among the more serious ophthalmic conditions are eyelid lacerations (44), which require surgical intervention because of the risk of structural and functional complications affecting the eye. Such injuries may also be accompanied by corneal ulcers, globe perforation, uveitis, orbital fractures, cellulitis, or orbital abscess formation (8, 44, 58). These factors indicate the absolute necessity of immediate treatment. In more severe cases involving damage to the eyeball, it may be necessary to perform enucleation, that is, remove the entire contents of the orbit (58, 69). However, this procedure may be associated with numerous complications, particularly due to the specific anatomical structure of the region or in cases of advanced pathological changes (47). The most commonly reported complications include intraoperative bleeding, wound infection, suture dehiscence, and the formation of cysts or inclusion granulomas within the orbit.

Equine colic – risk of surgery. Among the most commonly reported emergency cases in horses are gastrointestinal diseases, particularly colic (10, 89, 92). According to Viljoen et al. (89), these conditions account for approximately 64% of equine emergencies, of which nearly 23% require surgical intervention.

One-year survival rates following colic surgery range from 60% to 90%, and the vast majority of horses are able to return to their intended use, often achieving performance equal to or even exceeding their preoperative level (20, 21, 52, 64, 67, 70). However, despite continuous improvements in survival rates, the risk of complications and mortality remains high (20). Based on the analysis of medical records from a clinic in the United States, Matthews et al. (70) reported that as many as 27.6% of cases were euthanized during surgery or died before recovery from anesthesia. In contrast, Gandini and Guisto (32), after excluding horses euthanized for financial reasons or those that died prior to surgery, reported a mortality rate of 4% during the procedure and an additional 12.8% between successful surgical intervention and discharge from the clinic.

It is estimated that approximately 45-50% of horses undergoing colic surgery experience at least one complication (32, 70). The most commonly reported complications include recurrent colic, postoperative infections, incisional hernia, peritonitis, postoperative laminitis, as well as behavioral or performance-related issues (32, 52, 65). The risk of complications depends on multiple factors, including advanced age (85). The authors indicated that the risk of complications or mortality for horses older than 14 years was more than twice as high as that for horses aged 10-14 years. Owners are also more likely to opt for euthanasia rather than surgery in older horses compared to younger ones (30). A different perspective was presented by Gandini and Guisto (32), who found no differences in long-term survival between older and younger animals. Body condition may be an even more important factor (85). It has been demonstrated that a body condition

score (BCS) below 4 may predispose horses to adverse outcomes. Therefore, an evidence-based approach is essential to optimize treatment planning and surgical techniques in order to achieve the best possible clinical outcomes (32). Early diagnosis and prompt initiation of treatment may improve overall survival (85). It should be noted, however, that due to the loss of follow-up with owners, the reported results did not include the entire original study population. Consequently, the reported percentages may be either overestimated or underestimated (32, 66, 70, 85). Additionally, comparisons of survival rates and complications following colic surgery between different centers may be challenging because of regional differences in management conditions, as well as variations in data classification and reporting among authors (4, 32, 34, 85).

Another challenge associated with surgical procedures is the frequent occurrence of perioperative infections (27, 39). These may lead to serious complications and even death. Infections of the surgical site following laparotomy have been reported in over 25% of cases. The risk of infection depends primarily on the type and load of bacteria present at the surgical site, as well as on environmental and procedural factors (17, 53). It is also important to note that a potentially higher risk is observed in orthopedic surgery compared to soft tissue surgery.

Appropriate use of antibiotic prophylaxis can significantly reduce the risk of perioperative infections (93). On the other hand, improper selection or overuse of antibiotics may contribute not only to the development of antimicrobial resistance, but, in some cases, may even promote the occurrence of infection itself (39, 93).

Organization and equipment of the operating room

Minimizing the risk of nosocomial infections and improving overall treatment outcomes require optimal conditions within the operating room (42). The structure of the facility and available infrastructure should be designed according to the specific nature of procedures performed (73). The central area of the clinic should be located in close proximity to operating rooms equipped with anesthetic systems, allowing for rapid patient transfer (50). Additionally, the spatial layout must take into account the need for a preparation area and a recovery room. These areas are recommended to be adjacent, parallel, and longitudinally arranged, which facilitates logistics and patient flow management (77). Operating departments should also be divided into progressive zones with decreasing levels of contamination, from the entrance to the operating rooms (3, 77, 83).

The operating room should be divided into at least four functional zones: the main surgical room, a preparation area with a surgical scrub station, a changing area or space for donning protective clothing, and a designated area for used surgical equipment (50). This layout ensures better control of opportunistic pathogens, which may spread at least partially by air (83). The presence of such pathogens increases the risk of perioperative infections. Maintaining appropriate air quality also requires an effective ventilation system that regulates temperature, humidity, and the concentration of contaminants and microorganisms below established thresholds (81). Such measures reduce the risk of infection and improve working conditions for personnel. According to the guidelines of the Polish Ministry of Agriculture and Rural Development (72), the minimum area of such a room should be 35 m², and its height should be at least 2.5 m, so as to ensure adequate access to the patient and proper placement of surgical equipment.

Floors and walls in operating rooms must be constructed from materials that are easy to clean and resistant to disinfectants (50). They must also be waterproof and impermeable, which facilitates cleaning and disinfection to maintain sterile conditions and minimize the risk of infection. Various finishing materials may be used for this purpose, such as epoxy resins (7). Walls should be white in color to facilitate identification of potential contamination (50). Furthermore, the installation of properly designed drainage systems in the flooring significantly facilitates maintenance of cleanliness and safe removal of surgical fluids (29). However, their presence does not directly reduce the risk of infection in patients.

Equipping the operating room to meet strict hygiene standards requires the implementation of modern technologies and remains a significant challenge in the rapidly evolving field of veterinary medicine. Proper spatial organization is crucial for the safety of the patient safety and the efficiency of veterinary staff (22). The main surgical room should not contain an excessive number of unnecessary furnishings, in order to limit areas where dust may accumulate (3, 50, 77). Ideally, all equipment should be made of stainless steel, which is durable and easy to disinfect. Additionally, appropriate arrangement of surgical instruments and the use of adjustable operating tables enhance the working comfort of veterinary surgeons.

Summary

Although the success rate of equine veterinary surgery is high, the incidence of complications remains considerable. Improving anesthetic safety is of critical importance, particularly with regard to methods that enable safe recovery from general anesthesia. The type of anesthesia is selected according to the type of procedure, its complexity, the preferences and capabilities of the surgical team, and the temperament of the horse. Despite ongoing efforts to reduce recovery-related complications, mechanical injuries occurring during this phase are still reported. Pain assessment scales may also prove useful, facilitating earlier detection of abnormalities associated with patient welfare. Furthermore, optimization of perioperative procedures is essential,

with particular emphasis on maintaining a sterile surgical environment, as airborne microorganisms represent one of the causes of postoperative wound infections. Equine veterinary surgery thus continues to pose a significant clinical challenge, requiring further research and optimization of existing procedures.

References

1. *Abass M., Picek S., Garzón J. F. G., Kühnle C., Zaghlou A., Bettschart-Wolfensberger R.*: Local mepivacaine before castration of horses under medetomidine isoflurane balanced anaesthesia is effective to reduce perioperative nociception and cytokine release. Equine Vet. J. 2018, 50, 733-738.
2. *Abernathy-Young K. K., LeBlanc M. M., Embertson R. M., Pierce S. W., Stromberg A. J.*: Survival rates of mares and foals and postoperative complications and fertility of mares after cesarean section: 95 cases (1986-2000). J. Am. Vet. Med. Assoc. 2012, 241, 927-934.
3. *Andersson A. E., Bergh I., Karlsson J., Eriksson B. I., Nilsson K.*: Traffic flow in the operating room: An explorative and descriptive study on air quality during orthopedic trauma implant surgery. Am. J. Infect. Control. 2012, 40, 750-755.
4. *Archer D. C., Pinchbeck G. L., Proudman C. J., Clough H. E.*: Is equine colic seasonal? Novel application of a model-based approach. BMC Vet. Res. 2006, 2, 27.
5. *Åkesson T.*: The incidence of post-operative colic in adult equine patients undergoing elective non-abdominal surgery at SLU and potential risk factors. Master thesis, Swedish University of Agricultural Sciences, Uppsala 2023.
6. *Barreto da Rocha P., Driessen B., McDonnell S. M., Hopster K., Zarucco L., Gozalo-Marcilla M., et al.*: A critical evaluation for validation of composite and unidimensional postoperative pain scales in horses. PLoS One. 2021, 16, e0255618.
7. *Berrow M., Brooks A., Kotowska A. M., Watts J., Riordan L., Kidger L. et al.*: Development and characterisation of antimicrobial epoxy resin. Sci. Rep. 2025, 15, 12463.
8. *Betbeze C. M., Dray S. M., Fontenot R. L.*: Subconjunctival enucleation with orbital implant placement in standing horses: 20 cases (2014-2017). J. Am. Vet. Med. Assoc. 2021, 258, 661-667.
9. *Bonomelli N., Bonilla A. G.*: Standing surgery among equine board certified surgeons: Survey regarding current use and trends. Equine Vet. J. 2023, 55, 1045-1057.
10. *Bowden A., Burford J. H., Brennan M. L., England G. C. W., Freeman S. L.*: Horse owners' knowledge, and opinions on recognising colic in the horse. Equine Vet. J. 2020, 52, 262-267.
11. *Bramlage L. R.*: Operative orthopedics of the fetlock joint of the horse: Traumatic and developmental diseases of the equine fetlock joint, [in:] AAEP Annual Convention, AAEP Proceedings, vol. 55, American Association of Equine Practitioners, Las Vegas 2009.
12. *Brooks D. E.*: Complications of ophthalmic surgery in the horse. Vet. Clin. North Am. Equine Pract. 2008, 24, 697-734.
13. *Brumund L., Wittenberg-Voges L., Rohn K., Kästner S. B. R.*: Risk assessment in equine anesthesia: a first evaluation of the usability, utility and predictivity of the two-part CHARIOT. Front. Vet. Sci. 2024, 11, 1384525.
14. *Byrne C. A., Hotchkiss J. W., Barakzai S. Z.*: Variations in the application of equine prosthetic laryngoplasty: A survey of 128 equine surgeons. Vet. Surg. 2023, 52, 209-220.
15. *Campoy L., Martin-Flores M., Araos J., Parry S. A., Gleed R. D.*: A newly developed recovery-enhancing device improves recovery scores during emergence from general anesthesia in horses: a randomized trial. Am. J. Vet. Res. 2024, 85.
16. *Cender A. N., Mählmann K., Ehrle A., Merle R., Pieper L., Lischer C. J.*: Diagnosis and outcome following tenoscopic surgery of the digital flexor tendon sheath in German sports and pleasure horses. Equine Vet. J. 2023, 55, 48-58.
17. *Cerullo A., Di Nicola M. R., Scilimati N., Bertoletti A., Pollicino G., Moroni B., Pepe M., Nannarone S., Gialletti R., Passamonti F.*: Intra- and post-operative bacteriological surveys of surgical site in horses: A single-centre study. Microorganisms 2025, 13, 928.
18. *Chaney K. P., Holcombe S. J., LeBlanc M. M., Hauptman J. G., Embertson R. M., Mueller P. E., Beard W. L.*: The effect of uterine torsion on mare and foal survival: a retrospective study, 1985-2005. Equine Vet. J. 2007, 39, 33-36.
19. *Chapman H. S., Richardson D. W., Ortved K. F.*: Arthrodesis of the metacarpophalangeal and metatarsophalangeal joints to treat osteoarthritis in 17 horses. Vet. Surg. 2019, 48, 850-857.
20. *Christophersen M. T., Dupont N., Berg-Sørensen K. S., Konnerup C., Pihl T. H., Andersen P. H.*: Short-term survival and mortality rates in a retrospective study of colic in 1588 Danish horses. Acta Vet. Scand. 2014, 56, 20.
21. *Christophersen M. T., Tnibar A., Pihl T. H., Andersen P. H., Ekstrom C. T.*: Sporting activity following colic surgery in horses: a retrospective study. Equine Vet. J. 2011, 40, 3-6.
22. *Corbera J. A., Melián Henríquez A., Morales Doreste M., Martín Martel S., Tejedor-Junco M. T.*: Implementing evidence-based biosecurity protocols in Veterinary Teaching Hospitals: a critical review and guide for best practices. Anim. Health Res. Rev. 2025, 26, e5.
23. *Davis J. A., Bopp A. C., Henwood M. K., Bean P., Grau J. W.*: General anesthesia blocks pain-induced hemorrhage and locomotor deficits after spinal cord injury in rats. J. Neurotrauma 2023, 40, 2552-2565.
24. *Drewnowska O., Hecold M., Turek B.*: Monitoring koni podczas znieczulenia ogólnego przy ograniczonych warunkach aparaturowych. Życie Wet. 2014, 89, 766-769.
25. *Domańska-Kruppa N., Benoit P., Żukiewicz-Benoit K., Domino M., Kliczkowska K., Szubart M., Stefanik E.*: Behavioral and orthopedic issues in geldings with postcastration adhesions: A retrospective study of 35 cases. Res. Vet. Sci. 2025, 196, 105910.
26. *Douglas H., Midon M., Shroff K., Floriano D., Driessen B., Hopster K.*: Caudal epidural catheterization for pain management in 48 hospitalized horses: A descriptive study of demographics, complications, and outcomes. Front. Vet. Sci. 2022, 9, 995299.
27. *Dória R. G. S., Freitas S. H., Laskoski L. M., Arruda L. P., Shimano A. C.*: Correlation between peritonitis and incisional infections in horses. J. Equine Vet. Sci. 2020, 87, 102903.
28. *Dugdale A. H., Obhrai J., Cripps P. J.*: Twenty years later: a single-centre, repeat retrospective analysis of equine perioperative mortality and investigation of recovery quality. Vet. Anaesth. Analg. 2016, 43, 171-178.
29. *Durant A. M., Whitney M. A., Chang Y. H. H., Larson M. A., Shah P. H., Lyon T. D., Tyson M. D., et al.*: Surgical site infections in open and laparoscopic operations in rooms with open-floor drainage systems. Urol. Pract. 2023, 10, 622-629.
30. *Elane G. L., Blikslager A. T., Mair T. S.*: Trends in the management of horses referred for colic evaluation preceding and during the COVID-19 pandemic (2013-2023). Equine Vet. Educ. 2025, 37, 308-315.
31. *El-Sherif M. W.*: Laparoscopic castration in stallions with two different testicular blood vessels occluding techniques. J. Hell. Vet. Med. Soc. 2019, 70, 1429-1434.
32. *Gandini M., Giusto G.*: Evaluation of long-term postoperative morbidity and survival after equine colic surgery using a complication severity classification. Vet. Rec. 2026, e1-e7.
33. *Gasiorowski J. C., Richardson D. W.*: Diagnostic and therapeutic arthroscopy in the standing horse. Vet. Clin. North Am. Equine Pract. 2014, 30, 211-220.
34. *Giusto G., Cerullo A., Labate F., Gandini M.*: Incomplete ileocecal bypass for ileal pathology in horses: 21 cases (2012-2019). Animals 2021, 11, 403.
35. *Gozalo-Marcilla M., Redondo J. I., Bettschart-Wolfensberger R., Domenech L., Doménech J., Johnston G. M., Taylor P. M.*: The confidential enquiry into perioperative equine fatalities: phase 4 (CEPEF4) – a worldwide observational, prospective, multicentre cohort study in 2025. Vet. Anaesth. Analg. 2025, 52, 525-538.
36. *Gozalo-Marcilla M., Ringer S. K.*: Recovery after general anaesthesia in adult horses: A structured summary of the literature. Animals 2021, 11, 1777.
37. *Gozalo-Marcilla M., Bettschart-Wolfensberger R., Johnston M., Taylor P. M., Redondo I. J.*: Data collection for the fourth multicenter confidential enquiry into perioperative equine fatalities (CEPEF4) study: New technology and preliminary results. Animals 2021, 11, 2549.
38. *Górski K., Bereznowski A., Turek B., Kłos Z., Kliczkowska-Klarowicz K.*: Włókniak zakaźny kikuta powrózka nasiennego – rzadkie powikłanie po kastracji koni. Życie Wet. 2024, 12, 12-10.
39. *Griessel T. S., Muñoz Morán J. A., Byaruhanga C., Smit Y.*: A single-centre retrospective study of surgical site infection following equine colic surgery (2013-2021). Vet. Rec. 2025, 196, e5227.
40. *Grosbois C. E. de, Boissy Saint Léger F.*: Laryngeal hemiplegia in the horse: an update. Preventie en behandeling van longworm (A. vasorum) bij honden. Vlaams Diergeneeskd. Tijdschr. 2018, 87, 283.
41. *Hackett E. S., McOnie R. C., Buote N. J., Fubini S. L.*: Current practices in equine minimally invasive soft tissue surgery. Vet. Surg. 2025, 54, 59-67.
42. *Hardy J.*: Design and organization of an equine intensive care unit. Vet. Clin. North Am. Equine Pract. 2004, 20, 1-10.
43. *Haussler K. K.*: Pressure algometry for the detection of mechanical nociceptive thresholds in horses. Animals 2020, 10, 2195.
44. *Hendrix D. V. H.*: How to repair eyelid lacerations, [in:] AAEP Annual Convention, Nashville, AAEP Proceedings, vol. 59, American Association of Equine Practitioners 2013, p. 149-154.
45. *Hernandez A. N. A., Hendrix J. M.*: Epidural anesthesia, [in:] StatPearls [Internet]. StatPearls Publishing 2025.

46. *Herthel T. D., Rick M. C., Judy C. E., Cohen N. D., Herthel D. J.*: Retrospective analysis of factors associated with outcome of proximal interphalangeal joint arthrodesis in 82 horses including Warmblood and Thoroughbred sport horses and Quarter Horses (1992-2014). Equine Vet. J. 2016, 48, 557-564.
47. *Hewes C. A., Keoughan G. C., Gutierrez-Nibeyro S.*: Standing enucleation in the horse: a report of 5 cases. Can. Vet. J. 2007, 48, 512-514.
48. *Hillyer M. H., Taylor F. G., French N. P.*: A cross-sectional study of colic in horses on thoroughbred training premises in the British Isles in 1997. Equine Vet. J. 2001, 33, 380-385.
49. *Hodgson C., Pinchbeck G.*: A prospective multicentre survey of complications associated with equine castration to facilitate clinical audit. Equine Vet. J. 2019, 51, 435-439.
50. *Holgate A. C.*: Ideal surgical suite design. Vet. Nurs. J. 2013, 28, 218-219.
51. *Hussni C. A., Watanabe M. J., Alves A. L. G., Nicoletti J. L. D. M., Vulcano L. C.*: Tenotomia do músculo flexor digital superficial e desmotomia acessória em equinos: goniometria radiometacarpiana, metacarpofalângica e interfalângica. Ci. Anim. Bras. 2010, 11.
52. *Immonen I. A. M., Karikoski N., Mykkänen A., Niemelä T., Junnila J., Tulamo R. M.*: Long-term follow-up on recovery, return to use and sporting activity: a retrospective study of 236 operated colic horses in Finland (2006-2012). Acta Vet. Scand. 2017, 59, 5.
53. *Isgren C. M., Salem S. E., Archer D. C., Worsman F. C., Townsend N. B.*: Risk factors for surgical site infection following laparotomy: Effect of season and perioperative variables and reporting of bacterial isolates in 287 horses. Equine Vet. J. 2017, 49, 39-44.
54. *Janerka C., Nosaka K., Alejandro A. L., Hughes J., Azlan N. R., Rashidi A., et al.*: Emergency clinicians' knowledge and practice of pain assessment for older adults with cognitive impairment: A cross-sectional study. Australas. Emerg. Care 2026.
55. *Jehle M. C., Biermann N. M., Haltmayer E.*: Trephination versus minimally invasive transnasal approaches for the diagnosis and treatment of sinus disease in horses. Vet. Sci. 2022, 9, 334.
56. *Johnston G. M., Eastment J. K., Wood J., Taylor P. M.*: The confidential enquiry into perioperative equine fatalities (CEPEF): Mortality results of Phases 1 and 2. Vet. Anaesth. Analg. 2002, 29, 159-170.
57. *Kilcoyne I., Watson J. L., Kass P. H., Spier S. J.*: Incidence, management, and outcome of complications of castration in equids: 324 cases (1998-2008). J. Am. Vet. Med. Assoc. 2013, 242, 820-825.
58. *Knickelbein K. E., Stock M., Carrasco S. E., Reilly C. M., Lassaline M. E.*: Traumatic phacocele in an American miniature horse. Vet. Ophthalmol. 2019, 22, 61-66.
59. *Koenig J., McDonell W., Valverde A.*: Accuracy of pulse oximetry and capnography in healthy and compromised horses during spontaneous and controlled ventilation. Can. J. Vet. Res. 2003, 67, 169-174.
60. *Lang J. J., Li X., Micheler C. M., Wilhelm N. J., Seidl F., Schwaiger B. J., et al.*: Numerical evaluation of internal femur osteosynthesis based on a biomechanical model of the loading in the proximal equine hindlimb. BMC Vet. Res. 2024, 20, 188.
61. *Laurenza C., Ansart L., Portier K.*: Risk factors of anesthesia-related mortality and morbidity in one equine hospital: A retrospective study on 1,161 cases undergoing elective or emergency surgeries. Front. Vet. Sci. 2020, 6, 514.
62. *Lean N. E., Sole-Guitart A., Ahern B. J.*: Laryngeal tie-forward in standing sedated horses. Vet. Surg. 2023, 52, 229-237.
63. *Leps A., Korsos S., Clarysse M., Vlaminck L.*: Dental sectioning for intraoral equine cheek teeth extractions: 29 cases. Front. Vet. Sci. 2024, 11, 1367861.
64. *Linden M. A. Van Der, Laffont C. M., van Oldruitenborgh-Oosterbaan M. M. S.*: Prognosis in equine medical and surgical colic. J. Vet. Intern. Med. 2003, 17, 343-348.
65. *Loon J. P. A. M. van, Van Dierendonck M. C.*: Pain assessment in horses after orthopaedic surgery and with orthopaedic trauma. Vet. J. 2019, 246, 85-91.
66. *Loon J. P. A. M. van, Macri L.*: Objective assessment of chronic pain in horses using the horse chronic pain scale (HCPS): A scale-construction study. Animals 2021, 11, 1826.
67. *Loon J. P. van, Visser E. M., de Mik-van Mourik M., Kerbert P., Huppes T., Menke E. S.*: Colic surgery in horses: a retrospective study into short- and long-term survival rate, complications and rehabilitation toward sporting activity. J. Equine Vet. Sci. 2020, 90, 103012.
68. *Madhok B., Nanayakkara K., Mahawar K.*: Safety considerations in laparoscopic surgery: A narrative review. World J. Gastrointest. Endosc. 2022, 14, 1-16.
69. *Marzok M., Almubarak A. I., Nazih M., Al-thnaian T. A., Alkhodair K., El-Sherif M.*: A novel enucleation–exenteration approach of the equine eye via the supraorbital fossa: an experimental and clinical study in donkeys (Equus asinus). Front. Vet. Sci. 2024, 11, 1379151.
70. *Matthews L. B., Sanz M., Sellon D. C.*: Long-term outcome after colic surgery: retrospective study of 106 horses in the USA (2014-2021). Front. Vet. Sci. 2023, 10, 1235198.
71. *McIlwraith C. W., Foerner J. J., Davis D. M.*: Osteochondritis dissecans of the tarsocrural joint: results of treatment with arthroscopic surgery. Equine Vet. J. 1991, 23, 155-162.
72. Ministerstwo Rolnictwa i Rozwoju Wsi: Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 16 sierpnia 2004 r. w sprawie wymagań dla klinik weterynaryjnych. Dz. U. 2004, nr 194, poz. 1993.
73. *Ozgok Y.*: Planning and designing of an ideal animal laboratory set up for surgical training. Curr. Opin. Urol. 2015, 25, 175-181.
74. *Parkin T. D. H., Brown J., Macdonald E. B.*: Occupational risks of working with horses: A questionnaire survey of equine veterinary surgeons. Equine Vet. Educ. 2018, 30, 200-205.
75. *Racine J., Vidondo B., Ramseyer A., Koch C.*: Complications associated with closed castration using the Henderson equine castration instrument in 300 standing equids. Vet. Surg. 2019, 48, 21-28.
76. *Rebière de Pouyade G. de la, Binard M., Deleuze S., Ponthier J.*: Survey on outcomes of emergency standing caesarean section in equids. Front. Vet. Sci. 2025, 12, 1548978.
77. *Rezapoor M., Alvand A., Jacek E., Paziuk T., Maltenfort M. G., Parvizi J.*: Operating room traffic increases aerosolized particles and compromises the air quality: A simulated study. J. Arthroplasty. 2018, 33, 851-855.
78. *Salciccia A., de Pouyade G. D. L. R., Caudron I., Ponthier J., Serteyn D., Sandersen C., et al.*: Surgical closure of equine abdomen, prevention, and management of incisional complications. J. Vis. Exp. 2024, 207, e65546.
79. *Samsel J.*: Chirurgiczna korekcja skrętu macicy poprzez laparotomię na koniu stojącym. Pięć przypadków klinicznych. Życie Wet. 2020, 95, 489-493.
80. *Samsel J., Gündemir O., Szara T., Witkowski M.*: Midline vs. flank laparotomy-criteria for choosing the optimal surgical technique for uterine torsion correction in the mare. BMC Vet. Res. 2025, 21, 542.
81. *Saran S., Gurjar M., Baronia A., Sivapurapu V., Ghosh P. S., Raju G. M., Maurya I.*: Heating, ventilation and air conditioning (HVAC) in intensive care unit. Crit. Care 2020, 24, 194.
82. *Schweinsberg L., Ehrle A., Schweinsberg U., Meehan L., Cender N., Lischer C.*: Single-cut osteotomy for correction of a complex multiplanar deformity of the radius in a Shetland pony foal. Vet. Surg. 2021, 51, 148-156.
83. *Shaw L. F., Chen I. H., Chen C. S., Wu H. H., Lai L. S., Chen Y. Y., Der Wang F.*: Factors influencing microbial colonies in the air of operating rooms. BMC Infect. Dis. 2018, 18, 4.
84. *Souza A. F. de, Paretsis N. F., De Zoppa A. L. D. V.*: Proximal interphalangeal arthrodesis in horses: a meta-analysis of retrospective studies. J. Equine Vet. Sci. 2023, 122, 104226.
85. *Spadari A., Gialletti R., Gandini M., Valle E., Cerullo A., Cavallini D., Bertoletti A., Rinnovati R., Forni G., Scilimati N., et al.*: Short-term survival and postoperative complications rates in horses undergoing colic surgery: A multicentre study. Animals 2023, 13, 1107.
86. *Straticò P., Guerri G., Palozzo A., Varasano V., Petrizzi L.*: Current use of equine laparoscopy in urogenital disorders: A scoping review of the literature from 2000 to 2021. Vet. Sci. 2022, 9, 41.
87. *Tulloch J. S., Schofield I., Jackson R., Whiting M.*: 'It's only a flesh wound' – understanding the safety culture in equine, production animal and mixed veterinary practices. Prev. Vet. Med. 2025, 241, 106541.
88. *Vandaele Z., Van den Broeke C., Merchiers A., Schauvliege S.*: The use of an air-inflated pillow for assisted recovery after general anaesthesia in horses: A preliminary study. Animals 2025, 15, 564.
89. *Viljoen A., Saulez M. N., Donnellan C. M., Bester L., Gummow B.*: After-hours equine emergency admissions at a university referral hospital (1998-2007): causes and interventions. J. S. Afr. Vet. Assoc. 2009, 80, 169-173.
90. *Witkowski M., Turek B., Tischner M.*: Skręt macicy u klaczy – diagnostyka, techniki operacyjne, rokowanie. Med. Weter. 2017, 73, 124-128.
91. *Woods A.*: From one medicine to two: The evolving relationship between human and veterinary medicine in England, 1791-1835. Bull. Hist. Med. 2017, 91, 494-523.
92. *Wormstrand B. H., Ihler C. F., Diesen R., Krontveit R. I.*: Surgical treatment of equine colic – a retrospective study of 297 surgeries in Norway 2005-2011. Acta Vet. Scand. 2014, 56, 38.
93. *Zychska M., Rzewuska M., Kizerwetter-Swida M., Chrobak-Chmiel D., Stefanska I., Kwiecien E., Witkowski L.*: Antimicrobial resistance in bacteria isolated from diseased horses in Poland, 2010-2022. Pol. J. Vet. Sci. 2025, 28, 292-302.

Corresponding author: