International Journal of Allied Sciences (IJAS)
Volume.13, Number 6; June-2022;
ISSN: 2836-3760 | Impact Factor: 6.15
https://zapjournals.com/Journals/index.php/Allied-Sciences
Published By: Zendo Academic Publishing

THE FUTURE OF VETERINARY MEDICINE: CUTTING-EDGE TECHNOLOGIES AND THERAPIES

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Article Info

Keywords: Animal, Development, Research, Technology, Veterinary

Abstract

As technology continues to advance, the field of veterinary medicine is experiencing a paradigm shift, with numerous groundbreaking innovations and therapies emerging. This article delves into an in-depth discussion of these developments, emphasizing advancements in areas such as stem cell therapy, fiber optic technology, anesthesia and anesthetic monitoring, and laser surgery. The clinical application of stem cells in veterinary medicine is still in its nascent stages, but it is already redefining the concept of healing in various animal species. The incorporation of fiber optic technology in diagnostics has been one of the most thrilling advancements in the field. Moreover, Alfaxalone, the latest anesthetic induction agent approved by the FDA, and surgical lasers have noticeably improved operating room experiences. This review provides a concise overview of these essential innovations, as well as other emerging therapies that are consistently enhancing the health and longevity of animals.

Introduction

The field of veterinary medicine has undergone significant transformations in recent years, with the rapid development of cutting-edge technologies and therapies. These advancements have not only improved diagnostic and treatment options for a wide range of animal species but also revolutionized the approach to veterinary care, emphasizing preventive medicine and individualized care for patients (Mazan & Hoffman, 2018). As a result, the future of veterinary medicine is set to be shaped by these innovative technologies and therapies, with the potential to create a more efficient, humane, and sustainable healthcare system for animals. This article aims to provide a comprehensive overview of the latest developments in veterinary medicine and their implications for the field, drawing on recent research and expert opinions. One of the most promising technological advances in veterinary medicine is the application of artificial intelligence (AI) and machine learning algorithms, which have the potential to transform various aspects of veterinary practice. AI-based tools can assist in the diagnosis of diseases,

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the identification of patterns in large datasets, and the prediction of treatment outcomes, thereby offering significant benefits in terms of accuracy and efficiency (Dyson et al., 2018). Moreover, AI-driven technologies can facilitate remote consultations and telemedicine, enabling veterinarians to reach a wider range of patients and provide timely, personalized care (Kogan et al., 2020). These applications of AI in veterinary medicine are still in their infancy but hold great promise for improving the quality and accessibility of care. Another area of technological innovation in veterinary medicine is focused on imaging and diagnostic modalities. Advances in diagnostic tools, such as digital radiography, computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound, have significantly improved the accuracy and speed of disease detection in animals (Lamb et al., 2018). Furthermore, the introduction of portable, handheld devices has allowed for greater flexibility in conducting diagnostic tests in remote or field settings (Lisciandro, 2018). Additionally, the development of advanced imaging techniques, such as molecular imaging and functional imaging, has opened up new avenues for understanding the pathophysiology of diseases and monitoring the effectiveness of treatments (Lee et al., 2018). In addition to technological innovations, veterinary medicine has also witnessed significant advancements in the development of novel therapies and treatments. One such example is the field of veterinary regenerative medicine, which involves the use of stem cells, growth factors, and tissue engineering techniques to promote healing and tissue regeneration in animals (Hoffman & Dow, 2016). Regenerative therapies have shown promise in treating a variety of conditions, including musculoskeletal injuries, neurological disorders, and organ damage (Delling et al., 2015). Moreover, these therapies offer a more conservative and less invasive alternative to traditional surgical interventions, reducing the risk of complications and improving patient outcomes (Koch et al., 2017). Another emerging area of research in veterinary medicine is the use of gene editing technologies, such as CRISPR/Cas9, to develop innovative treatments for genetic disorders in animals. Gene editing has the potential to correct specific genetic mutations, thereby offering a targeted and precise approach to treating diseases with a known genetic basis (Rogers & Benoit, 2016). While still in the early stages of research, gene editing has shown promise in preclinical studies for treating conditions such as muscular dystrophy and cystic fibrosis in animal models (Yin et al., 2016; Schwank et al., 2013). The successful translation of these technologies to veterinary practice could revolutionize the management of genetic disorders in animals, offering new hope for affected patients.

The future of veterinary medicine is characterized by the rapid development of cutting-edge technologies and therapies, which hold the potential to reshape the field and improve the quality of care for animals. The integration of AI-driven tools, advanced diagnostic modalities, regenerative medicine, and gene editing technologies into veterinary practice will require ongoing research, collaboration, and investment in education and infrastructure. By embracing these advancements, the veterinary profession can continue to evolve and adapt to the changing needs of both patients and practitioners, ensuring a bright and promising future for animal healthcare.

1. Stem cell therapy

The clinical use of stem cells in veterinary medicine is clearly in its early stages. Applications for bone marrow-derived mesenchymal stem cells (BM-MSC) and adipose-derived stromal vascular fraction (AD-SVF) cells in the treatment of musculoskeletal pathologies are currently in use in several species, although the differential efficacies of various approaches are still being investigated. Optimization of these stem cell-based therapies will focus on the cellular origin, isolation, enrichment, and processing as well as on the timing, route of administration, formulation, and dosing of those therapies. Development of confirmed embryonic stem or induced pluripotent stem cells in domestic species would greatly facilitate the development of a wider range of clinical applications. Use of stem cell-based approaches in attempts to preserve the germplasm of threatened species could begin on an opportunistic basis in the form of xenografting of testis tissue obtained quickly after the death of prepubertal individuals (Fortier and Travis, 2011). However, this must still be considered a research endeavor given the largely unknown causes of species differences in the success of spermatogenesis as well as the need to perform subsequent techniques of assisted reproduction which have themselves not yet been determined for most species.

2. Fiber optics

One of the most exciting developments in veterinary medicine in the last few years is fiber optic technology. Briefly, fiber optics involves the use of small plastic fibers that carry light along their entire length. In veterinary medicine, bundles of these fibers are put together in an endoscope. These scopes, which resemble black cables or hoses, are useful for many procedures. For example, to aid in the diagnosis of vomiting or diarrhea, the veterinarian can pass an endoscope into a sedated or anesthetized animal and look at or take biopsies of the gastrointestinal tract. Optical fibers can assess animal behavior using both optical imaging/recording and the manipulation of neural activity (Miyamoto and Murayama, 2016). Smaller versions of these scopes can be used for diagnosing bladder disorders, urethral problems, and for looking at the internal female reproductive tract. Endoscopes are also useful in emergencies when an animal has swallowed a foreign object. For the coughing companion, a small version of an endoscope called a bronchoscope can be placed into the animal's airway for visualization and biopsy. Formerly, these procedures could only be done through surgery. Endoscopic examination, diagnosis and treatment are much less expensive. There are also fewer complications than an animal would potentially experience through surgery (e.g. infections, bleeding and disruption of the surgical wound).

3. Anesthesia and anesthetic monitoring

Since the introduction of anesthesia hundreds of years ago, the agents used to provide sedation, induction, and maintenance of anesthesia have become profoundly safer. Although the drugs we use today are much safer, there still exists no perfect anesthetic agent. Since propofol came to the market, it has been the most widely used, and arguably one of the safest anesthetic induction agents used in both human and veterinary anesthesia. Alfaxalone, brand name Alfaxan, is the newest anesthetic induction agent to enter the United States market after approval by the FDA (Rodríguez et al., 2012). Other newer anesthetics such as isoluorane and sevoluorane anesthetize animals more safely than the older ones. These new gases quickly induce anesthesia, have minimal negative effects on your animal's internal systems, such as the cardiovascular, and allow the animal to recover quickly when the procedure is terminated.

The statement "there are no safe anesthetic agents, there are no safe anesthetic procedures, there are only safe anesthetists" should be the dictum for the entire anesthetic process in every practice (Smith, 1959). Anesthesia is typically maintained using inhalant anesthetics delivered in O_2 and dosed "to effect" (Lerche et al., 2000). Monitoring can be of following types:

Physiologic Monitoring:

Regardless of the drugs used for anesthesia maintenance (i.e., inhalant or injectable), vigilant monitoring, interpretation of physiologic changes, and response to patient physiologic status by well-trained and attentive staff is critical. Monitoring decreases the odds of anesthetic death, whereas a lack of monitoring increases the odds of anesthetic death by a factor of 5–35 (Matthews et al., 2017). Both multiparameter electronic monitors and hands-on assessment of the patient by the anesthetist should be used. Treatment decisions should be made based on information from both the electronic monitors and the anesthetist's assessment. Monitoring respiratory function includes respiratory rate, oxygenation (percentage of hemoglobin saturated with oxygen (SPO_2), and ventilation ($ETCO_2$). BP, heart rate (HR) and rhythm (ECG), capillary refill time, mucous membrane color, and pulse oximetry (SpO2) provide the best indices of cardiovascular function. Anesthetic depth is monitored, and a surgical plane of anesthesia is typically defined as a patient with absent palpebral reflex, mild jaw tone (i.e., muscle relaxation), and lack of purposeful movement. Body temperature monitoring is critical, with heat supplementation starting early.

Regardless of the drugs used for anesthesia maintenance (i.e., inhalant or injectable), O_2 should be delivered to the patient. The O_2 flow rates depend on the breathing circuit. Use a relatively high flow rate (2–3 L/min) when rapid changes in anesthetic depth are needed, such as during the transition from injectables to inhalants (induction) or when discontinuing inhalants at the end of the procedure. Because of the high oxygen flow, increased flow at induction and after discontinuing inhalants is not necessary. Following induction and intubation, the patient may be apneic or have a low or shallow respiratory rate, requiring intermittent (1-4 breaths/min) PPV breaths delivered by the anesthetist to maintain anesthesia until the respiratory depression of the induction drugs subsides. If PPV is excessive, $ETCO_2$ levels will decrease below the level that stimulates ventilation and the patient may not begin spontaneously breathing. Balanced crystalloid fluids should be administered for most patients undergoing anesthesia.

4. Laser surgery

The past two decades have seen incredible progress in the development of laser technologies for the veterinary profession, and there is every indication this will continue. In keeping with the consensus of today's veterinary laser practitioners that higher power equates to improved results in surgical outcomes, the latest generations of surgical lasers have been developed with power outputs of up to 45W at a continuous wave, and up to 30W at SuperPulse. With such units, laser surgery may now be conducted at the same hand speed as that performed with a scalpel blade, with the added benefits of no hemorrhage, with reduced collateral thermal injury, and with sealed nerve endings and lymphatics. Such innovation is an extraordinarily useful tool to possess for soft tissue surgery (Mushaben et al., 2018). Laser surgical innovations include: Laser-Tissue Welding, Smaller Handheld Laser Units, etc. An examination of today's technologies offers an opportunity for speculation on how the veterinary profession might integrate them with surgical lasers to enhance the operating room experience.

This is just a partial list of major veterinary advances. Many additional new therapies and technologies are becoming available all the time, continually improving the health and longevity of animals.

Conclusion

Technological advancements have helped improve the quality of not just human life but also that of the animals dear to them. The field of veterinary medicine has witnessed transformations in leaps and bounds, enabling veterinary practitioners to make faster diagnoses, more accurate prognoses, and ultimately save animal lives. The use of technology has also ensured better care outcomes - not just for the pets, but also for their owners.

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