Advancements and challenges in pediatric neurosurgery: An analysis of treatment techniques for children with neurological disorders

https://doi.org/10.56238/sevened2023.007-012

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1 INTRODUCTION

Pediatric neurosurgery is a specialized field that focuses on the surgical treatment of neurological disorders in children. Advances in technology and surgical techniques have significantly improved outcomes for children with neurological disorders. However, there are still obstacles to be overcome in this field.

The objective of this chapter is to provide an overview of the advancements and challenges in pediatric neurosurgery and explore the various treatment techniques available for children with neurological disorders. In this article, we will examine the advantages and disadvantages of each treatment technique, the risks and complications associated with each technique, and how the outcomes of each treatment can be enhanced.

Through this research, we hope to provide a comprehensive understanding of the current state of pediatric neurosurgery and the potential for future advancements in this field.

2 OVERVIEW OF PEDIATRIC NEUROSURGERY

2.1 WHAT ARE THE ADVANCEMENTS IN PEDIATRIC NEUROSURGERY?

In recent years, there have been significant advances in pediatric neurosurgery, making it a rapidly expanding field in the medical community. Due to the multidisciplinary nature of this field and the need for advocacy, it is essential to provide medical students with the necessary resources to learn about pediatric neurosurgery. To do this, there are various online resources for medical students, including webinars, courses, journals, simulations, and social media.

However, there are few resources specifically aimed at medical students. Therefore, additional educational resources designed to capture the interest of medical students and incorporate neurosurgical knowledge with special applicability to the medical student population are needed.

Virtual education has several advantages, such as accessibility, convenience, up-to-date nature, incorporation of multimedia, minimal cost, and customization. Furthermore, educational resources that incorporate elements of global health will help develop a commitment to global neurosurgery.

2.2 WHAT ARE THE OBSTACLES IN PEDIATRIC NEUROSURGERY?

The fact is that in many parts of Asia and Australasia, pediatric neurosurgery has not yet been recognized as a specialty. The vast geographical expanse and marked differences in economic conditions and healthcare systems have made it challenging to standardize the level of pediatric neurosurgical care. Moreover, the current shortage of workforce in pediatric neurosurgery, particularly in low- and middle-income countries, is a significant obstacle.

In many high-income countries, adult neurosurgeons often provide treatment for pediatric patients with traumatic brain injury and brain tumors, and there is a need for general neurosurgeons to continue training in the management of pediatric neurosurgical conditions. Additionally, there is minimal knowledge about the prevalence of specialized pediatric neurocritical care services, and the skill sets and training needs in pediatric neurosurgery differ from one country to another, depending on the economic situation.

There is also the issue of the lack of structured referral systems in pediatric neurosurgery, which means that pediatric neurosurgeons do not receive referrals from pediatricians and general practitioners. Furthermore, due to the healthcare payment model in certain countries, general neurosurgeons may end up performing "simple" pediatric operations, further reducing the volume of cases handled by specialists. Therefore, obstacles in education and training in pediatric neurosurgery need to be addressed to ensure that training needs are adequately met, and the number of pediatric neurosurgery fellowship programs should be increased in Asia and Australasia.

2.3 WHAT TREATMENTS ARE AVAILABLE FOR CHILDREN WITH NEUROLOGICAL DISORDERS?

To further complicate the situation, there is little consensus on when Deep Brain Stimulation (DBS) should be offered for pediatric dystonia, a neurological disorder. DBS is a novel technology that offers direct neuromodulation for the treatment of pediatric neurological disorders. It has been implemented in some children with primary generalized dystonia, but its acceptance and application are still limited.

There are other treatments for children with neurological disorders, such as neuropsychological assessments to improve psychomotor disorders and dedicated residential facilities for the care of children and adolescents with neurological disorders. Advances in diagnostic tests, such as electroencephalography, neuroimaging, electromyography, muscle histology, biochemistry, and

molecular biology, are helping diagnose and treat a wide range of conditions. There are clinics with specialized multidisciplinary interest in pediatric neurological problems, and Cook Children's Medical Center has developed a dedicated pediatric program for neurological disorders, but very few programs are exclusively dedicated to children with neurological disorders.

Dietary and enzyme replacement therapies are used to treat many neurometabolic disorders, and for detailed information, Scriver et al.'s compendium (12) should be consulted. Phenylketonuria can be treated through dietary therapy, and enzyme replacement therapy is used for storage diseases like Gaucher's disease.

3 TREATMENT TECHNIQUES FOR CHILDREN WITH NEUROLOGICAL DISORDERS

3.1 WHAT ARE THE ADVANTAGES AND DISADVANTAGES OF EACH TREATMENT TECHNIQUE?

Focused Ultrasound-Induced Blood-Brain Barrier Disruption (FUS-BBBD) is a non-invasive treatment technique being investigated for neurological diseases. This therapeutic window is relatively short, and commercially available human systems are extremely expensive. Additionally, adaptations such as immobilization and acoustic coupling are required when using FUS systems for animal use. Furthermore, additional therapeutic planning procedures must be considered due to inter- and intra-animal variability in cranial geometry and density.

Currently, there are no commercially available FUS systems designed for companion animals, and diseases that require chronic drug administration may require multiple treatment sessions. Intrathecal (IT) morphine is an effective analgesic for dogs, although it has adverse reactions such as itching and urinary retention. A single injection of IT morphine can provide postoperative pain relief in dogs undergoing major abdominal or thoracic surgery.

IT cytarabine and methotrexate are often used to treat hematological malignancies, primary brain tumors with leptomeningeal dissemination, or immune-mediated meningoencephalitis, with the most common adverse event being self-limited headache. IT drug administration is an advantageous technique for the treatment of CNS neoplasms in both humans and animals. SPECT and PET are two bedside methods, with the former being cheaper and more accessible but with low resolution and requiring a long examination time, and the latter having high resolution but being expensive and using ionizing radiation.

Interstitial injections and biodegradable implants provide high local drug concentrations in the brain but also have disadvantages, such as drug distribution depending on interstitial diffusion and limited distribution in the brain parenchyma. Non-invasive transient transcranial BBB disruption can be achieved using low electric field PEF, and patient-specific treatment plans are required for IRE and HFIRE to achieve safe and effective ablations. IRE- and HFIRE-BBBD are invasive due to electrode

placement in the brain, and HFIRE can be used for ablation of numerous naturally occurring canine tumors, including brain tumors, resulting in a peripheral zone of BBBD around the ablated core that can be used to deliver therapeutic agents to the tumor margin.

3.2 WHAT ARE THE RISKS AND COMPLICATIONS ASSOCIATED WITH EACH TREATMENT TECHNIQUE?

However, medical students need to have a basic understanding of the risks and complications associated with different treatment techniques. Postoperative cerebrospinal fluid leaks can result in culture-positive meningitis. Patients who have undergone prior radiation therapy or surgical interventions are at increased risk for this complication. To address this, lumbar drainage, wound revision, and/or lumboperitoneal shunting may be necessary. Additionally, operations involving intradural dissections may lead to an increased chance of cerebrospinal fluid leaks or pseudomeningocele.

Reoperation for recurrence may involve increased morbidity due to increased adhesions caused by radiation. Destruction of microvasculature can lead to increased susceptibility to new surgical traumas. Radiation, in addition to increased adhesion, can also cause reactive gliosis and fibrosis, hardening of ependymoma, disruption of natural dissection planes, and destruction of microvasculature. There are also potential complications associated with radiation therapy.

Pathological features of radiation myelopathy include asymmetric demyelination of the lateral columns, coagulative necrosis, decreased glial response, and arteriolar wall proliferation. This has led to the limitation of postoperative radiation use in certain surgical centers. Radiation therapy can also lead to radiation myelopathy, resulting in severe damage to the nervous system. Furthermore, this can progress further to lower motor neuron syndrome, marked by irreversible muscle atrophy, bilateral weakness, and decreased reflexes.

Lastly, radiation targeted to the entire craniospinal region should only be performed in cases of metastatic disease to avoid unnecessary risks. Dysesthetic syndrome is also a potential complication, occasional mild sensations of numbness or pins and needles, while others experience persistent dysesthesias described as "itching," "crawling," or "burning."

3.3 HOW CAN THE OUTCOME OF EACH TREATMENT TECHNIQUE BE IMPROVED?

To enhance the outcomes of each treatment technique, modern technology offers a variety of options to healthcare professionals. Recording quantitative measures in each session or task is a great way to monitor the course of treatment. It also provides the therapist with objective and real-time measures of the patient's motor capabilities. Additionally, kinematic measures obtained by sensors in

robots can be used to provide greater objectivity, repeatability, accuracy, and ease of application in assessing motor recovery.

This technology allows the therapist to obtain real-time objective measures of the patient's motor capabilities, which in turn can help track the patient's progress, assess the effectiveness of different interventions, and adapt to the specific motor recovery trend of the patient. Therefore, the use of technology in pediatric neurosurgical care will be essential to improve the outcomes of each treatment technique.

4 FINAL CONCLUSIONS OF THE TEXT

Pediatric neurosurgery is a rapidly expanding field that holds much promise for children with neurological disorders. However, there are still several obstacles and challenges that must be addressed to ensure that children receive the best possible care.

One of the main obstacles is the lack of resources available to medical students interested in pediatric neurosurgery. While there are several online resources available, few are specifically aimed at medical students. This limits opportunities for students to learn about the field and develop a commitment to global neurosurgery. Moreover, marked differences in economic conditions and healthcare systems make it challenging to standardize the level of pediatric neurosurgical care in many parts of Asia and Australasia.

In many parts of Asia and Australasia, pediatric neurosurgery has not yet been recognized as a specialty, which further exacerbates the problem. Another challenge is the lack of structured referral systems in pediatric neurosurgery, which means that pediatric neurosurgeons do not receive referrals from pediatricians and general practitioners. Additionally, it is necessary for general neurosurgeons to continue training in the management of pediatric neurosurgical conditions, especially in areas where pediatric neurosurgery has not yet been recognized as a specialty.

The use of modern technology, such as Deep Brain Stimulation (DBS) and real-time objective measures of a patient's motor capabilities, can significantly improve the outcomes of each treatment technique. However, additional therapeutic planning procedures must be considered due to inter- and intra-animal variability in cranial geometry and density.

In conclusion, obstacles in education and training in pediatric neurosurgery must be addressed to ensure that training needs are properly met, and the number of pediatric neurosurgery fellowship programs should be increased in Asia and Australasia. By doing so, children with neurological disorders can receive the best possible care and outcomes.

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