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Review Article

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Robotic Surgery in the Brain: A Review

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ABSTRACT
Intubation failure is often experienced in neurosurgery cases involving craniotomy under general anesthesia. This has the potential to cause airway patents and death. The aim of this study was to determine the relationship between Mallampati score and intubation. A total of 33 patients who were going to undergo neurosurgery, as respondents, applied the inclusion and exclusion conditions. Mallampati and intubation procedures were observed in the operating room using an observation sheet. The data obtained were analyzed using the Chi-square test with a confidence level of 95%. The results showed that there was a significant relationship between the Mallampati score and the success of intubation with a correlation coefficient of 0.707, p value 0.000. In conclusion, Mallampati score, especially grade 1-2, has the potential to achieve successful intubation compared to grade 3-4. Health workers who are responsible for carrying out neurosurgery in craniotomy cases need to be aware of the Mallampati score to save the patient.

Introduction
The human brain is an extraordinarily complex organ responsible for controlling nearly every aspect of the body's functions [4]. As such, surgeries involving the brain require extreme precision, skill, and care. Traditional brain surgeries, although effective, often come with significant risks, including the potential for damage to surrounding tissues, longer recovery times, and a higher likelihood of post-operative complications [5]. The advent of robotic surgery has introduced a paradigm shift in the way neurosurgeons approach brain surgery. Robotic systems, such as the da Vinci Surgical System, the ROSA robot, and the NeuroArm, have brought about significant advancements in surgical precision, control, and outcomes.

The Evolution of Robotic Surgery
Robotic surgery is not a new concept; its origins date back to the late 20th century, when the first robotic-assisted surgeries were performed [6]. However, it was not until the early 21st century that robotic surgery began to gain widespread acceptance in the medical community. The initial focus was primarily on minimally invasive surgeries in areas such as urology and gynecology. However, as technology advanced, so too did the applications of robotic surgery, extending into more complex and delicate fields such as neurosurgery.

In neurosurgery, precision is paramount. Even the slightest error can lead to catastrophic consequences, including paralysis, loss of cognitive function, or death [7]. Robotic surgery addresses these challenges by offering a level of precision that is difficult to achieve with the human hand alone. Robotic systems are equipped with high-definition, 3D imaging capabilities and are capable of translating a surgeon's movements into micro-movements, allowing for unparalleled control during surgery.

Technological Advancements
The integration of robotics in brain surgery has been made possible by several key technological advancements. One of the most significant is the development of sophisticated imaging systems that provide real-time, high-resolution images of the brain during surgery. These imaging systems, often combined with computer-assisted navigation, allow surgeons to visualize the exact location of a tumor or other abnormality and plan the best approach for removal.

Robotic systems used in brain surgery are typically equipped with multiple articulated arms, each capable of performing different tasks. For example, one arm might hold an endoscope, providing a clear view of the surgical site, while another arm holds a surgical instrument, such as a scalpel or cauterizing tool.

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These arms are controlled by the surgeon from a console, where they can manipulate the instruments with precision and dexterity.

Another important technological advancement is the development of haptic feedback systems, which provide the surgeon with tactile sensations during surgery. This allows the surgeon to "feel" the tissue they are operating on, providing an additional layer of control and safety. Haptic feedback is particularly important in brain surgery, where distinguishing between healthy and abnormal tissue is crucial.

Applications of Robotic Surgery in Neurosurgery

Robotic surgery has a wide range of applications in neurosurgery, from tumor removal to deep brain stimulation (DBS) and epilepsy surgery. One of the most common applications is the removal of brain tumors. Traditionally, brain tumor removal required large craniotomies (surgical openings in the skull) and carried a high risk of damaging surrounding brain tissue. Robotic systems allow for much smaller incisions and more precise removal of tumors, minimizing damage to healthy tissue and reducing recovery time [8].

Deep brain stimulation (DBS) is another area where robotic surgery has had a significant impact. DBS involves the implantation of electrodes in specific areas of the brain to treat neurological conditions such as Parkinson's disease, dystonia, and essential tremor. The precision required for electrode placement is critical, and robotic systems have greatly improved the accuracy of this procedure, leading to better patient outcomes [9].

Conclusion

Robotic surgery has transformed neurosurgery, offering unparalleled precision, control, and outcomes in brain surgery. The integration of advanced robotics with real-time imaging and computer systems has enabled surgeons to perform complex procedures with minimal invasiveness, reducing recovery time and improving patient care. While there are challenges and limitations to consider, the future of robotic surgery in neurosurgery is bright, with ongoing research and development aimed at further enhancing the capabilities of these systems. As technology continues to advance, robotic surgery is likely to play an increasingly important role in the treatment of brain disorders, offering new hope to patients and revolutionizing the field of neurosurgery [10].

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