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BMH Medical Journal 2016;3(2):51-54 **Brief Review**

Robotic Telesurgery: Benefits Beyond Barriers

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Introduction

The idea of robotic telesurgery dates back to the 1970s when the National Aeronautics and Space Administration (NASA) developed a project to utilize remotely controlled robots to perform surgeries on astronauts [1]. The history of robotic surgery begins in 1985, when Kwoh et al used a robot - Puma 200, for performing neurosurgical biopsies with greater precision [2]. This was soon followed by the introduction of PROBOT in 1988, a robotic system for ultrasound guided prostatic resection [3]. A major breakthrough in the field of robotic surgery came with the performance of the first transatlantic telesurgical procedure (Operation Lindbergh) by a surgeon in the United States operating on a patient in France. Laparoscopic cholecystectomy was performed on a 68-year-old lady in Strasbourg, France by Professor Marescaux utilising a Zeus robotic system located in New York, USA. There were no complications during the procedure and the patient was discharged 2 days later [4]. Since then, telesurgery has been carried out in multiple locations around the globe with successful outcomes.

Methods

Eligibility criteria: Literature search was conducted to identify trials and review articles describing the origin, implementation and latest developments in the field of robotic telesurgery. Special focus was placed on studying the information technology required for setting up of a telesurgery system.

Information sources and searches: Searches were conducted using PubMed. Additional articles were identified from bibliographies of the articles obtained using the PubMed search. Searches were not limited to any time period. Articles were identified using the keywords "telesurgery" OR "telerobotics".

Study selection: Articles retrieved were assessed for their eligibility for inclusion in the study by screening their titles and abstracts.

Results and discussion

A telerobotic system is composed of 'master' control console from which the surgeon operates and a 'slave' unit which performs surgery on the patient using robotic arms. The early designs were limited in their scope due to basic computer interfaces. Data transmission speed is a major obstacle in performing long distance telesurgeries [1]. A significant limitation in robotic telesurgery is communication latency. Round trip latency is the time between the initiation of a movement and the appearance of the image in the surgeon's monitor [5]. During the first successful transatlantic robotic telesurgery, Marescaux J et al [4] were able to minimize latency by using a dedicated communication line provided by France Telecom. Even though the round trip distance for data transmission was 14000 Km, the network latency was only 155ms. There was no significant impact on the ability to perform fine surgical movements at this latency level. The communication line used terrestrial fiber-optic network with asynchronous transfer mode (ATM) technology. But dedicated ATM lines were expensive with yearly cost ranging from $100,000 to $200,000 [4].

In addition to the high cost of ATM lines, the availability is poor in remote and rural areas. Satellite connections (with latency of about 500ms) and Virtual Private Networks (VPN) with variable latency are the most commonly available networks. Anvari et al [6] did a study to evaluate the impact of latency of the performance of surgical tasks without clinically important errors. Surgeons were asked to complete surgical tasks with latencies of 0ms, 175ms, 300ms and 500ms latencies. Order of latencies were randomized and surgeons were blinded to the latency figures. There was significant increase in task completion time with increasing latencies. It was also associated with significant increase in the number of errors [6].

The first telerobotic remote surgical system was setup in Canada by Anvari et al [7]. It was established in 2003 between St. Joseph's Hospital in Hamilton and North Bay General Hospital 400 km away. Surgeons operated the Zeus-TS surgical system in North Bay from a console in Hamilton. Unlike the expensive ATM network used by Marescaux J et al [4], a commercially available IP-VPN (Internet Protocol-Virtual Private Network) with 15 Mbps of bandwidth was used here. This was the same system used for local internet services. The service included an active line and a redundant backup line to be used in case of failure of the active line. Telesurgery data transmission was given the highest priority in the network, thus ensuring the most rapid data rate possible. The overall latency was 135-140 ms. Of this, 14 ms was due to delay in the network and the rest was due to delay in compression and decompression of video signals. Although the latency was noticeable to the surgeon, he was able to adapt to it easily. A total of 21 surgeries were performed and there were no major complications [7].

Of the seven clinical trials identified during literature search, only one involved the use of remote telesurgical procedures. Another study evaluated the use of remote ultrasound guidance using robotic arms. Other studies were not found to be relevant and were excluded from the study.

Challacombe B et al [8] compared human versus robotic and telerobotic access to the kidney in percutaneous nephrolithotomy. They used a validated kidney model for comparing human and robotic modes. Although they found robotic insertion to be slower than human insertion (56.5s vs 35s), robotic mode was found to be more accurate (first attempt success 88% vs 79%). Trans-Atlantic robotic procedures done via Integrated Services for Digital Network (ISDN) lines also produced comparable results [8].

Bruyere F et al [9] studied the use of telerobotic arms to perform ultrasound guidance during renal biopsy in transplant recipients. They demonstrated the feasibility of tele-operated ultrasound-guided renal biopsies. But the time required was significantly increased compared to conventional technique. There were no post-biopsy complications [9].

Possibly, the ultimate application of robotic telesurgery is the one proposed by NASA in the 1970s - telesurgery in space. The challenges faced in the implementation of such a system include: performing surgery in reduced gravity conditions, portable equipment and most importantly, the latency in long range data transmission. The feasibility of using robotic surgery in zero gravity has already been demonstrated. In September 2007, NASA successfully tested M7, a light and portable robotic device developed by Stanford Research International. Parabolic flights were used to simulate zero gravity. Telesurgical procedures in space controlled from earth will be limited by light speed data transmission. For Earth-Moon distance, this will translate into a delay of about 1 second, which will only be suitable for basic telesurgical procedures [1].

Conclusion

Information technology has the potential to revolutionize the field of surgery. Patients in remote areas can have access to the latest surgical procedures through robotic telesurgery. The benefits of telesurgery extends beyond geographic barriers. Telementoring programs will allow training of surgeons in performing complex procedures. It also opens avenues for international surgical collaboration. Development of faster computer networks will allow reduction in data transfer latency and allow surgeries to be performed over longer distances. But more clinical trials should be carried out to compare the outcome of telesurgery with conventional modalities. Even though high cost of implementing and running a telesurgery system was initially a deterrent, decrease in cost of components and services are paving the way for wider implementation.

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