



High Intensity Focused Ultrasound (HIFU) Telesurgery Play a Role in “Digital Healthcare” – The First 5G-Backed HIFU Ablation Procedures

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Introduction

The coronavirus pandemic in the year 2020 has forced healthcare providers worldwide to adopt or initiate the use of digital solutions [1]. Doctors are advised to reduce face-to-face appointments with patients who might display symptoms of COVID-19 infection, like cough, running nose, headache, and weakness [2,3]. While historical medical model requiring doctor-patient interactions in clinics and hospitals are severely affected, hundreds to thousands of patients requiring medical consultations and subsequent surgeries would not be allowed to get into doctors’ clinics or hospitals. At the same time, all public medical facilities and hospitals are fully utilized to cope with the COVID-19 crisis and to minimize the risks of cross infections of this very infectious disease. The medical systems in many western countries had reached a breakdown crisis. Moreover, all elective surgeries, including cancer surgeries, are postponed or cancelled, even to the demise of the whole healthcare services. Vulnerable patients who need surgery with inadequate healthcare services can benefit from telesurgery development. The development of Robotic telesurgery is fairly well established [4]. However, it is because of the need for expensive equipment and advanced telecommunication system; they are only operable in the theatres in big hospitals, especially the need for surgeons whose expertise is available. However, the cost of robotic telesurgery is very expensive; not only one must pay for a costly robotic system for up to USD 2 million, the expenditure of instruments generally costs anywhere from USD 3,000 to 6,000 more than traditional laparoscopic surgery. The cost effectiveness is very low [5,6]. We reported the world’s first HIFU telesurgery through the 5G network in Shanghai, China. We would also highlight the future digital development of the HIFU telesurgery with the limitations of this digital procedure in healthcare development.

The Patient and Procedure

A 44 years old female patient, who presented with multiple uterine fibroids resulting in heavy menstrual flows and anemia, was referred to interventional department for HIFU ablation treatment. MRI showed three intramural and two subserous fibroids ranging from 3 cm to 5 cm (Figure 1A, 1B). She was admitted to Central City Hospital on October 13th, 2019 for pre-HIFU assessment and planning. According to the Institutional Ethics Committee approval, written informed consent for the US-guided HIFU telesurgery was obtained from this patient. On October 13th, 2019, on the day of HIFU treatment, after adequate bowel and pre-HIFU skin preparations, the patient was positioned lying prone in the treatment bed of a HIFU model JC200. The ultrasound-guided image of the uterus was assessed, and a treatment plan developed by a specialist who was physically presented at the office of Shanghai International Medical Center, located about 30 kilometers away in

Shanghai. He remotely controlled a 5G-backed slave focused ultrasound equipment at the Central City Hospital, treating the patient at an operating room (Figure 2). The whole procedure was performed under sedation analgesia, lasting 52 min duration with total sonication time of 770 sec under 150 to 180 Watt with 1:1 ablation rate (1s shot sonication with 1s cooling interval). The patient tolerated the ablation procedure well, and apart from mild sore pain at the treatment site, there was no complication. She was discharged home on 15 October 2019. A good result (Figure 1C and 1D) was achieved seamlessly in the environment of 5G fast-speed communication at very low latency (less than 20 ms), i.e., the delay from the doctor’s control console to the slave HIFU

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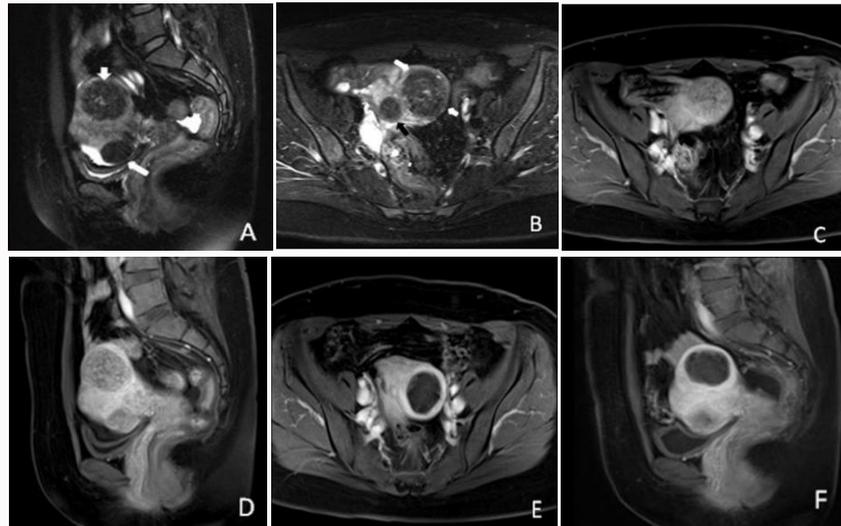


Figure 1: 44-year-old woman with multiple fibroids on MRI scan of the patient with before (A-D) and after (E,F) HIFU telesurgery.



Figure 2: Dr. Xu performed the HIFU telesurgery at Shanghai International Medical Centre for the patient with multiple fibroids at Central City Hospital 30 km away.

sonication shot. Coupled with China 5G development, Dr. Xu, one of the authors, had accomplished the world's first HIFU ablation telesurgery.

Discussion

Remote surgery (also known as telesurgery) is the operation performed by a doctor on a patient even though the operator(s) does not physically present at the same location. The rapid development of technology has allowed telesurgery to become highly specialized. Nowadays, the da Vinci surgical system was the first used robotic telesurgery system, Anvari et al. [7] after their first successful demonstrations of telerobotic surgeries; a hospital-to-hospital laparoscopic telesurgery service was established in Canada to serve telesurgery to patients in a rural community 400 km away. Compared to robotic telesurgery, HIFU telesurgery has the following advantages:

a) The cost is less expensive than robotic telesurgery because without the use of expensive laparoscopic instruments;

b) It does not need a traditional operating room and a team of back up surgeons;

c) Even if there are network or electricity outages, the risks to the patients are less without a surgical wound or any bleeding;

d) In case of emergency, the patient under HIFU ablation can be woken up without the reversal of general anesthesia yet, the implementation of HIFU telesurgery for remote areas still had not yet developed, since the issues of ablation accuracy and safety should be addressed.

The first HIFU telesurgery had been performed successfully in a remote location in this report. The two subserous fibroids of this case demonstrated accurate non-perfusion with safe edge after HIFU telesurgery (Figure 3). Some important areas of development have to be resolved before remote HIFU telesurgery is to be popular and feasible:

1. The lag time involved in HIFU telesurgery in areas with a

4G system exhibited delay issue, because any of patient movement that is difficult to control can be worrying, especially when there are inadequate analgesia and sedation, then accidental injury could occur. However, the high speed of 5G technology, the lag time of less than 20 ms appears to be insignificant.

2. The legal responsibility for any unexpected adverse outcome arising from system errors has to resolve.

3. Hackers must need much attention. The known risks of hackers can create a risk of interference with communications networks or image signals. When security and privacy in a digital HIFU tele-platform are being interfered with, it makes a tarnish on the record, which can interfere with the acceptance of this new HIFU telesurgery.

We are now at the crossway of a 'digital health' revolution. Various applications of telemedicine had become feasible, economical, and practical. The telemedicine market is expected to rise, and if the surgical areas are to be further developed, the therapeutic HIFU system will be able to offer the choice of long distant HIFU telesurgery soon. The recent COVID-19 pandemic is likely to precipitate the rapid development of this new treatment technology. The advantages of HIFU telesurgery *via* 5G network are to overcome.

1. Inadequate HIFU expert surgeon in remote or rural areas;
2. HIFU service accessibility - old patients and those with a compromised medical condition can avoid long-distance transportation for HIFU treatment;
3. When long distance travel or mobilization may not be possible, for example, in this COVID-19 pandemic, remote HIFU telesurgery will enable HIFU ablation to be completed.

Even before the end of this viral pandemic, we should be well prepared to cope with another viral pandemic in the future. At present, computing technologies are now changing the landscape of healthcare delivery and services [8]. We must now endorse this digital healthcare technology, which might help hospitals, doctors, and patients, to improve their access to care, surgery, and enhance collaboration, for the well-being of humanity. Digital incorporation in HIFU ablation is an opportunity to drive the Industry for more development. Since this case report, hopefully, future development, including additional

AI solutions to the present HIFU ablation system, will improve the effectiveness and safety of its treatment and enhance overall patient satisfaction. Finally, legal implications, patients' privacy issues, and medical responsibility have to be resolved before the widespread use of this area of development.

Conflict of Interest

All three authors are senior HIFU doctors teaching HIFU ablation techniques and have honorary affiliations with Chongqing HAIFU Medical Technology Company Ltd, Chongqing, China.

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