some notes on NOTES

Twenty years ago in Germany, Professor Kurt Semm was almost suspended from practicing surgery after removing a patient's appendix laparoscopically (otherwise known as 'keyhole surgery'). Initially vilified, Semm was a pioneer in minimally invasive surgery and was later praised for his early advances in a field that has become scientifically established and the gold standard procedure for certain operations. Ten years ago, all gall bladder removals were done via open surgery in the US. Today, nearly 98% of these cholecystectomies are performed laparoscopically. More recently (1997), the first single incision laparoscopic surgery (SILS) for cholecystectomy was reported.

For the patient, this means that instead of the large multi-centimetre scar of open surgery, there will - with laparoscopic surgery - be three small wounds of less than ten millimetres, or - with SILS - one small incision, for example on the umbilicus. All this means less scarring, shorter recovery times and less morbidity for the patient. However, as surgery becomes less and less invasive for the patient, it becomes more and more difficult for the surgeon and more and more challenging for the medical technologist. The surgeon needs to develop new skills and adapt to working in a different, somewhat sensory deprived environment. The technologist needs to develop instruments with greater degrees of freedom, reliable methods for closure of viscerotomy, better integration with imaging, better visualization (miniature cameras and lighting), and endoscopes flexible enough to manouvre to the organ of interest but, simultaneously, stiff enough such that the tip can be stabilized to actuate on the tissues. Achieving all these is a significant challenge.

During laparoscopic interventions, the surgeon does not have a direct view of the operating field as in open surgery. Instead, orientation is provided by laparoscopic images displayed on a monitor. Surgeons are used to working with an in-line view of the operating field provided by endoscopes where all instruments pass through parallel working channels. With multiple access ports, surgeons have to operate instruments which require counter-intuitive off-axis manipulation. Overcoming this spatial incongruity requires training and limits the speed of the procedure. The lack of direct access to the surgical site also means that the surgeon has no tactile feedback. Attempts to develop haptic instrumentation seem to have lost some momentum with current trends hinting that better visualization could make up for the loss of tactile information.

A new paradigm which has attracted great interest within the research community is that of Natural Orifice Translumenal Endoscopic Surgery (NOTES) and the broader field of Natural Orifice Surgery (NOS). At first glance, NOS seems just as crazy as Semm's early innovations. Using natural orifices of the body such as the esophagus, vagina, urethra, and anus as an entryway to the sterile inner viscera of the body sounds ludicrous and technically too difficult. But working groups of scientists and surgeons have been created to make it all happen, developing standards for the practice of these emerging techniques: the Natural Orifice Surgery Consortium for Assessment and Research (NOSCAR) for NOTES and the group formed by New European Surgical Academy (NESA) for NOS.

Is the enthusiasm of the academic community around NOS matched by their commercial counterparts?

Well, successful NOS approaches are already well-established in specific procedures such as TURP (Transurethral Resection of the Prostate). Interestingly, the world-first use of an autonomous robotic device to actively remove tissue from a patient - the Probot device developed at Imperial College London - was deployed in TURP. Incisionless interventions, based on Magnetic Resonance guided Focused Ultrasound (MRgFUS), have received FDA approval and are becoming more common for treatment of uterine fibroids amongst others. Existing commercial solutions for laparoscopic surgery, such as the da Vinci master/slave robot (Intuitive Surgical Inc., Sunnyvale, CA, USA) are multi-million-pound systems. Competitive offerings are appearing on the horizon, aiming to provide the haptic feedback features that are lost with the master/slave approach.

There are also attempts to develop lower-cost, procedure-specific assistive robots to deliver great value to the healthcare economy, some of which seek inspiration from biomimetics. Biologically inspired devices such as snake-like robots for colonoscopy and wasp-like ovipositor devices to penetrate tissue and, for instance, tiny devices that crawl across the surface of the brain and collect data about it, have been demonstrated.

Obviously, these research visions - some of which have been tested but all of which are still out of reach - require amazing things from the medical technologists to transform them into surgical instruments of the present.

Laparoscopic devices need a propulsion system, sensors to enable them to find the target, actuators to perform tasks on the target, a power source and communications capabilities to enable them to transmit information of their investigations and to receive control information from outside the body. Currently, the surgical staff fulfil these requirements but there are commercial efforts to develop technology which assists the surgeon, such as robotic tools and voice-activated systems. These are still far from the active strand of research which aims at developing devices the patient can 'swallow', and which can then target and treat tissues at a cellular level. This is a departure from current multi-million dollar, multi-function 'platform' robotics systems, towards low cost, specific function, even single-use, micro or nano devices. Whilst patient benefits will drive the long-term future of surgical technology, healthcare economics will play a major role in short- to medium-term developments.

It seems feasible that major surgery may one day be performed without skin incisions, using natural orifices as entry points for the surgical intervention, but there is certainly a lot of work to be done before the discipline can mature fully. Multidisciplinary teams are needed to develop the tools and methods required to ensure safe procedures as unforeseen complications, additional to those which may arise from open surgery and beyond those currently understood by the medical community, may develop. But at least it seems that the profession is more open to the possibilities of such innovative procedures than it was just 20 years ago. Could this mean that we start to realise the holy grail of true 'keyhole' surgery within the decade?

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