ALTERNATE HORIZONS PLATFORM

Scintillating surgery – Science behind surgery

Sarah Marianne McCausland

SPECIAL EDITION - 'SCINTILLATING SURGERY AND SCIENCE'

The word 'scintillating' is derived from the Latin words *scintillat* and *scintilla* meaning "to sparkle" and "a spark" respectively. These two abstractions fittingly illustrate the revolutionary technological advancements without which the advent of modern laparoscopic surgery would not be possible. Light relayed by specialised fibre optic systems and electrical current, utilized in diathermy, heralded a profound change in the way many surgical and gynaecological procedures could be performed, and ultimately enabled the emergence of what is now known as minimally invasive surgery. [1-3]

There has been a sustained increase in both the number and type of surgeries that are performed minimally invasively across a broad swath of surgical disciplines.[4] This essay will focus on laparoscopic surgery and explore two scintillating technologies that have enabled this surgical evolution.

Laparoscopy – a term that finds its roots in the Greek words *laparo* and *scopy* essentially means "to examine one's flank". Today, laparoscopy refers to minimally invasive surgery including purely diagnostic visualisation in the abdominal and pelvic cavities. Pioneer Kurt Semm performed the first laparoscopic appendectomy in Kiel in 1981. Initially, there was significant and persistent opposition from the surgical community with several of his peers attempting to get his medical licence revoked.[4-5] Since the 1980s, laparoscopy used in surgery has become the preferred method over open surgery for many commonly performed procedures.[1] This is particularly true for the field of gynaecology, where in some countries laparoscopic surgery accounts for the overwhelming majority of surgeries performed.[6]

There are numerous reasons for the increasing preference for laparoscopic surgery over open laparotomy. Firstly, with a smaller incision comes less bleeding, less post-operative pain, and fewer wound-associated complications. Furthermore, patients mobilize more rapidly and are discharged earlier. Fewer pulmonary complications and improved cosmesis are also added benefits of laparoscopic techniques compared to open laparotomy. For the surgeon, laparoscopy entails improved visibility as well as increased precision and accuracy when operating. Not unexpectedly, with new techniques arise new challenges. In the case of laparoscopy, surgeons sacrifice tactile feedback, manoeuvrability, and a 3-dimensional view of the operating field.[2,7]

For effective laparoscopy to be possible, several technological feats need to be accomplished. Of these, illumination of the peritoneal cavity, essential for safely performing laparoscopic procedures, is commonly achieved using fibre optics and modern bipolar diathermy devices which enable the equally important tight haemostatic control required to maintain good visibility. It must be noted, however, that other technological developments such as high-resolution miniature cameras, insufflation tubes, clips, clamps, and stapling technology have all synergised to improve modern laparoscopic methods.[8]

Fibre optics to most people, means fast internet. In the medical field, however, fibre optic systems play an integral role in the supply of light in laparoscopy as well as in the broader scope of endoscopy. Rudimentary fibre optics have been around since the nineteenth century, but its utilization in laparoscopy only became significant after 1954 following Harold H. Hopkins and N.S. Kapany's recognition of its potential value in endoscopy.[3]

The effectiveness of fibre optics to transmit light from one end of the fibre to the other can be attributed to total internal refraction. Light is refracted as soon as it reaches the interface between the core and the cladding surrounding this core in an optical fibre. Both the core and the cladding are comprised of glass, with the outer cladding layer having additives such as Boron to give it a slightly different refractive index that allows the propagation of light along the thin flexible fibre with minimal attenuation. [9] The thinness of the fibre enables the glass to bend much more without breaking than a thick glass rod could. For laparoscopic surgery, this means that surgeons can operate using flexible fibre optic illumination without the risk of having a hot light source directly in the abdomen and with very little loss of light along the fibre optic cables. Traditionally, coherent bundled fibre optics with identical fibre arrangements at the beginning and end of a cable were used to transmit a "true image" allowing for real-time observation. This has since been replaced in some areas of endoscopy with more modern technological innovations such as cameras. Incoherent fibre optics with unordered fibre arrangements, however, remain the most commonly used tool for high-density illumination in laparoscopy.[1,3]

Most people, including medical professionals, have very little understanding of how electrical current can be passed safely and usefully through the body. In the nineteenth century, French physician and physicist Jacques Arsene d'Arsonval discovered that at a high-frequency electrical current could be passed through the body without resulting in electric shock. Following this discovery, the first electrosurgical unit was created by William T. Bovie and Harvey Cushing during the 1920s.[10]

Modern diathermy makes use of a high-frequency alternating current through the human body to complete a circuit. If this current is concentrated at a point, a localized burn effect used for cutting, desiccation, fulguration and coagulation can be achieved. In monopolar diathermy current oscillates between the electrode directly used in the operating field to another fixed electrode placed elsewhere on the body. This method has limitations, there is a risk of severe burns at the sight of the return pad if it is not the correct size, or if it is not correctly in contact with the patient.[10] Additionally, monopolar diathermy must be used with extreme caution in patients with pacemakers or prostheses, as electricity could preferentially pass through these low electrical resistance objects with the current becoming concentrated, potentially resulting in internal burns, and furthermore interfering with the function of the pacemakers.[11] In contrast, bipolar diathermy confines the current only between the arms of the single forceps electrode. This has the advantage of reduced tissue damage via collateral spread and makes bipolar diathermy useful for more targeted surgery, including microsurgery.[10] Modern intelligent bipolar diathermy devices such as Ligature™ use a combination of pressure and precisely controlled electrical energy to seal tissue on either side of an integrated cutting blade, with minimal lateral thermal spread.[12] The majority of today's laparoscopic surgeries are performed with the aid of diathermy, either mono- or bipolar.[13]

In conclusion, the remarkable ability of hair-like glass filaments to efficiently transmit sparkling light, and the tremendous versatility of the spark of electricity manifested in modern diathermy devices (enabling unprecedented haemostatic control) have allowed for surgeons to operate in previously dark and dangerous places with confidence and safety. This, thereby, makes minimally invasive surgery a possibility for an ever-increasing number of procedures, ultimately reducing the burdens of pain and scarring that surgery places upon patients.

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