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MINI-REVIEW

How robotic surgery is changing our understanding of anatomy

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KEYWORDS

Robotic surgery;
Anatomy;
Laparoscopy;
Prostatectomy

ABBREVIATIONS

BNP, bladder neck preservation;
3D, three-dimensional;
DVC, deep venous complex;
NVB, neurovascular bundle;
RP, radical prostatectomy

Abstract The most recent revolution in our understanding and knowledge of the human body is the introduction of new technologies allowing direct magnified vision of internal organs, as in laparoscopy and robotics. The possibility of viewing an anatomical detail, until now not directly visible during open surgical operations and only partially during dissections of cadavers, has created a 'new surgical anatomy'. Consequent refinements of operative techniques, combined with better views of the surgical field, have given rise to continual and significant decreases in complication rates and improved functional and oncological outcomes. The possibility of exploring new ways of approaching organs to be treated now allows us to reinforce our anatomical knowledge and plan novel surgical approaches. The present review aims to clarify some of these issues.

A new medicine

Until 1500, surgery and anatomy were considered of little importance in comparison with other branches of medicine. In fact, until that century, professors had taught Anatomy simply by reading Galen's works *ex cathedra*. Although Galen was considered the standard authority on the topic, for religious reasons, he based most of his information on anatomy on what he saw when he dissected the bodies of animals, thus unintentionally making many gross errors.

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Modern anatomy saw the light of day in Padua, thanks to Andreas Vesalius, Professor of Surgery and Anatomy at the University of Padua from 1537. Vesalius believed that surgery had to be grounded in anatomy, and performed some dissections of human bodies. Only after a Paduan judge decided to make the bodies of executed criminals available for dissection did Vesalius start systematically to dissect and compare human bodies. He always performed the dissections himself and produced anatomical charts, as reference aids for his students. In 1543 (the same year which saw the publication of Nicolaus Copernicus' work on the revolutionary heliocentric theory), Vesalius published *De Humani Corporis Fabrica*, a revolutionary anatomical atlas based largely on human dissection, transforming anatomy into a sphere of knowledge which relied on observations taken from direct visualisation of the human body. Vesalius was the first to place particular importance on 'ocular evidence'.

Vesalius's disciples continued his work in Padua: his first student, Gabriele Falloppio, discovered the tubes, which are now named after him, the 'fallopian tubes'; and Girolamo Fabrici d'Acquapendente was the first to describe valves in veins. William Harvey later completed studies on circulation. Further progress was also made on many fronts, mainly by practising surgeons.

New tools

Antonio Vallisneri (1661–1730) was an Italian medical scientist, physician and naturalist, who held the chairs of Practical Medicine first and Theoretical Medicine later at the University of Padua.

In performing his animal studies and medical research, he decided to use some 'English microscopes with eight orders of lens' because, in his opinion, 'some objects are only visible with great patience and the eye armed with a very fine and perfect microscope' ('*e solo visibili con gran pazienza coll'occhio armato d'un finissimo e perfettissimo microscopio*').

The microscope allowed Vallisneri to discover and be the first to describe new structures in human subjects, such as spermatozoa ('*vermicelli spermatici*') [1], In the same way, in Padua, during long cold nights spent observing the heavens, in January 1610 Galileo Galilei discovered the first four moons of Jupiter ('*cosmica sidera*') 'armed with the first telescope' ('*cannocchiale*'). In both cases, a manufactured tool augmented the human power of vision, towards the two extremes of *very small* and *very large*.

In the field of surgery, the concept of an 'armed eye' augments our ability to see and identify much finer details in the surgical field, using optical magnification.

A new 'vision'

The most recent revolution in our knowledge and understanding of the human body is represented by the new technologies that allow us direct magnified views of organs, as in laparoscopy. The possibility of examining anatomical details, until now not directly visible during open surgical operations and only partially during post-mortem dissections, has created a 'new anatomy'. In fact, being able to see microscopic structures *in vivo* (rather than *ex vivo*) has greatly increased our knowledge of surgical anatomy.

The consequent refinements in operative techniques, as well as better views of the surgical field, have led to continual and significant decreases in complication rates and improvements in functional outcomes.

However, in some situations, improved views of laparoscopic surgery have not always been followed by better surgical work. This is the case, for example, of the real difficulty in placing a suture or performing a continuous suture using laparoscopic instruments. Only after a (very) long learning curve can an inexperienced surgeon place a single suture as well as an expert surgeon, who can quickly complete a long suture after only a few operations.

A new platform

Less than 20 years ago, another revolution profoundly changed our way of understanding, learning and consequently teaching anatomy: the introduction of robotic surgery with the da Vinci® Robot System (Intuitive Surgical, Sunnyvale, CA, USA). This platform is used in minimally invasive general surgery, paediatric surgery, gynaecology, otorhinolaryngology, and cardiothoracic surgery, although most robotic operations are planned for urological surgery.

One of the major advantages for surgeons using robots is the possibility of achieving sufficient skill in a (much) shorter time compared with laparoscopic surgery.

Until this revolution, surgeons in training always had to gain operative experience through 'supervised trial and error' on real patients, with consequent prolonged training (and sometimes compromising patients' safety!). With robotic systems, surgeons can practise operations in three-dimensional (3D) visual simulations, using soft-tissue models that re-create the textures of human tissues.

The development of specific and increasingly technologically advanced simulators has certainly shortened the learning curve and increased surgeons' skills, consequently improving results. In addition, special image-guided simulations allow naive surgeons to practise procedures on 3D reconstructions of the specific anatomical details of each patient.

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