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ORIGINAL ARTICLE

The ongoing emergence of robotics in plastic and reconstructive surgery

Chirurgie robot-assistée et chirurgie plastique et reconstructrice

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Muscular flap;
Latissimus dorsi flap;
Rectus abdominis flap;
Microsurgery;
supermicrosurgery

Summary Robot-assisted surgery is more and more widely used in urology, general surgery and gynecological surgery. The interest of robotics in plastic and reconstructive surgery, a discipline that operates primarily on surfaces, has yet to be conclusively proved. However, the initial applications of robotic surgery in plastic and reconstructive surgery have been emerging in a number of fields including transoral reconstruction of posterior oropharyngeal defects, nipple-sparing mastectomy with immediate breast reconstruction, microsurgery, muscle harvesting for pelvic reconstruction and coverage of the scalp or the extremities.

MOTS-CLÉS
Chrirugie robotique;
Chirurgie robot-assistée;
Robot chirurgical;
Chirurgie transorale

Résumé La chirurgie robot-assistée est de plus en plus utilisée en chirurgie urologique, digestive et gynécologique. L'intérêt de l'utilisation d'un robot chirurgical en chirurgie plastique, discipline qui s'opère le plus souvent en surface, n'est pas évident à première vue. Pour autant, les premières applications à la chirurgie plastique de la chirurgie robot-assistée sont en train d'émerger et concernent notamment la reconstruction des pertes de substance oropharyngées postérieures, la mastectomie conservatrice de l'aréole avec reconstruction mammaire

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robot-assistée;
Mastectomie conservatrice de l'aréole;
Lambeaux musculaires purs;
Lambeau de grand dorsal;
Lambeau de grand droit;
Microchirurgie;
Super microchirurgie

immédiate, la microchirurgie, le prélèvement de lambeaux musculaires purs pour le comblement d'exentérations pelviennes, la couverture des pertes de substance du scalp et des extrémités.

Introduction

Robot-assisted surgery was initially designed for military purposes, its objective being to develop a system enabling remote operations, otherwise known as telesurgery. In 1994, Phil Green, Richard Satava, Joe Rosen and the Stanford Research Institute (SRI) devised the Green Telepresence Surgery System, a system consisting in robotic arms that would eventually be operated remotely by means of a console and using a wireless connection [1]. The system was meant to equip a combat vehicle (Medical Forward Area Surgical Team, [MEDFAST]). The console was supposed to allow a surgeon to operate from a mobile hospital (Mobile Advanced Surgical Hospital, [MASH]) on a wounded soldier placed in a MEDFAST, up to 35 km away. During the same year, the surgeon Jon Bowersox [2] was responsible for the first intervention by telesurgery, a digestive anastomosis ex vivo on a pig intestine carried out from a work console installed in a MASH that controlled a surgical unit set up in a MEDFAST vehicle during a combat drill. The same technology was later employed to perform vascular anastomoses [3]. In 1996, Frederick Moll, an American surgeon and entrepreneur, acquired the technology developed by Phil Green at the SRI and founded Intuitive Surgical (Sunnyvale, CA), the company that would create the Da Vinci® robot, of which the initial version was commercialized in 1999. Today the robot is employed as a tool in numerous surgical specialties and has been emerging in the field of plastic surgery [4].

The da Vinci robot®

In 2000, the initial version of the da Vinci® robot obtained FDA approval for several digestive surgery and urological interventions. By 2003, the robot had been equipped with a fourth arm (da Vinci® SPTM). In 2006, the STM version was given approval for urological, digestive, gynecological, pediatric and thoracic surgery. By 2009, the da Vinci® SiTM could be equipped with two consoles, thereby, facilitating its formation. Finally, the most recent version was commercialized in 2014 (da Vinci® XiTM). The architecture of its arms was modified in view of facilitating multi-quadrant surgery without having to reposition the patient cart.

The da Vinci® robot consists in three elements (Fig. 1):

- the surgeon's console;
- the patient cart with its articulated or swivel arms;
- the imagery tower.

The patient cart consists in three (da Vinci® SiTM) or four (da Vinci® XiTM) arms. One arm supports the camera and the others are dedicated to the surgical instruments, which are equipped at their extremities with an articulation (Endowrist®) possessing 7 degrees of freedom; after having been utilized repeatedly, they require replacement.

The surgeon's console consists in a stereoscopic monitor providing a magnified, high-definition view of the surgical site. The endoscope contains two embarked cameras, each of which transmits images to a different eye, thereby, delivering to the operating field a three-dimensional image. An infrared sensor detects entrance into the console of the surgeon's head and unlocks the robot's arms. Master controls transmit the surgeon's hand motions, which guide the surgical instruments and the camera. The process is associated with a motion scaling system (ratio ranging from 1:1 to 5:1), and also with a filtration module designed to eliminate physiologic trembling. The foot pedal area includes several pedals dedicated to different types of coagulation (monopolar, bipolar, ultrasound), to camera movement regulation and finally, to a disengagement device enabling optimal repositioning of the instruments. The operator's console can also be coupled to a second working console that is capable, at any time and at the request of the operator, of transmitting hand motions. This means that during an operation, a novice surgeon can be accompanied by a mentor, thereby, enhancing safety and shortening the learning curve of the beginner.

The imagery tower contains a CO_2 insufflator and a luminous source. It is also equipped with a monitoring screen designed to transmit an image of the surgical site to observers and to staff situated beside the patient.

In comparison with conventional endoscopy, the advantages of the da Vinci® system are the following:

- stereoscopic vision: the da Vinci® system is equipped with technology providing the surgeon with three-dimensional visualization of the surgical site. Bove et al. [5] have demonstrated that surgical outcomes were improved in cases of laparoscopic radical prostatectomy when the operation was performed with three-dimensional vision of the surgical site. Moreover, stereoscopic vision partially compensates for the lack of effective feedback in present-day robotic systems, which means that seated at his work console, the surgeon manages without tactile information [6];
- dexterity: movements of the instruments are facilitated by articulated wrists allowing for 7 degrees of freedom