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UPDATE

# Transoral robotic surgery in head and neck cancer

S. Hans*, B. Delas, P. Gorphe, M. Ménard, D. Brasnu

*Service d'ORL et de chirurgie cervico-faciale, faculté de médecine Paris Descartes, Sorbonne Paris Cité, hôpital européen Georges-Pompidou, Assistance publique, 20, rue Leblanc, 75015 Paris, France*

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**Summary** Robots have invaded industry and, more recently, the field of medicine. Following the development of various prototypes, Intuitive Surgical® has developed the Da Vinci surgical robot. This robot, designed for abdominal surgery, has been widely used in urology since 2000. The many advantages of this transoral robotic surgery (TORS) are described in this article. Its disadvantages are essentially its high cost and the absence of tactile feedback. The first feasibility studies in head and neck cancer, conducted in animals, dummies and cadavres, were performed in 2005, followed by the first publications in patients in 2006. The first series including more than 20 patients treated by TORS demonstrated the feasibility for the following sites: oropharynx, supraglottic larynx and hypopharynx. However, these studies did not validate the oncological results of the TORS technique. TORS decreases the number of tracheotomies, and allows more rapid swallowing rehabilitation and a shorter length of hospital stay. Technical improvements are expected. Smaller, more ergonomic, new generation robots, therefore more adapted to the head and neck, will probably be available in the future.


## Introduction

Transoral robotic surgery (TORS) using the Da Vinci robot marketed by Intuitive Surgical® was initially developed in various surgical specialties (urology, gynaecology, cardiac surgery, etc.) and has been more recently introduced for the treatment of head and neck cancer. More than twenty studies have been published since 2005 on TORS in animals, cadavres and human subjects and in various head and neck cancer sites [1—7].

The first two parts of this review will describe the development of robotic surgery and the functioning of the Da Vinci robot, respectively. The third part analyses application of the Da Vinci robot to head and neck cancer and the preliminary results of published series. TORS is designed to reduce postoperative morbidity and improve quality of life. Prospective studies, especially in France, are underway to evaluate the oncological results.

## A brief history of robotic surgery

Following their creation in fiction, robots have invaded the industrial and military worlds. The word ''robot'' was used for the first time by the Czech writer Karel Capek in a science fiction play called Rossum's Universal Robots (RUR). Capek is recognized as having created science fiction well before it became a literary genre in its own right. In RUR, the

* Corresponding author.
*E-mail address:* stephane.hans@egp.aphp.fr (S. Hans).

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author imagined a future in which all workers are automats that only revolt once they have acquired a soul and become ''human''.

After being developed on industrial assembly lines, robots such as drones now play an essential role in war zones. In the medical field, the first robots were developed in rehabilitation medicine to help disabled patients. Robotic surgery was initially developed in the field of neurosurgery because of the rigid structure of the skull providing stable anatomical landmarks. Stereotactic surgery has been extensively developed since the beginning of the 1990s. Otological surgery also constitutes a field of robotic experimentation especially for stapedectomy.

Robotic surgery was first developed by the American armed forces. In the 1980s, in order to perform remote-controlled surgery on soldiers, the American armed forces, in partnership with Stanford University, California, developed a research programme that gave birth, in particular, to a start-up called Intuitive Surgical Inc. During the 1990s, three main types of robots were developed: Aesop and Zeus by Computer Motion Inc. and Da Vinci by Intuitive Surgical Inc. Intuitive Surgical Inc. subsequently acquired Computer Motion and currently has exclusive worldwide marketing rights.

The first surgical operation assisted by the Da Vinci robot, laparoscopic splenectomy, was performed in 1997. This procedure was followed by other applications: gastrectomy, splenectomy, oesophagectomy. Clinical studies demonstrated the feasibility of using a robot in these surgical procedures, but with no real benefit in terms of operating time, length of hospital stay, quality of surgical resection and quality of life for the patient compared to conventional laparoscopic surgery. Various disadvantages were reported: the cost of robotic surgery and the absence of tactile feedback preventing tactile control by the surgeon. The advantages were excellent vision in three dimensions and manipulation of instruments in three dimensions. The use of the Da Vinci robot was approved for use in laparoscopy by the Food and Drug Administration in 2000. Robotic surgery was progressively developed in urology, gynaecology, and thoracic surgery. Robotic surgery has occupied an important place in urology since the first prostatectomy performed in France by Professor Abbou's team at Mondor University Hospital in 2000 [8]. A study showed that robotic surgery allowed a more favourable postoperative course with decreased bleeding, decreased pain and a shorter length of hospital stay. Almost 65% of radical prostatectomies in the United States are now performed with the Da Vinci robot.

More than 25 Da Vinci® robots have been purchased by public or private hospitals in France and their number is on the increase.

## The Da Vinci robot

Use of a robot allows the surgeon to perform more complex operations than would be possible by conventional laparoscopic surgery. Robotic surgery has several advantages:

- three-dimensional vision versus two-dimensional vision in conventional laparoscopic surgery;
- stable vision, as the camera is maintained and mobilized by one of the articulated arms of the robot;
- more precise and finer instrument control with greater freedom of motion in all three dimensions;
- suppression of physiological tremor;
- finally, the surgeon is seated in the axis of the console, ensuring more favourable ergonomic conditions.

**Figure 1** Surgeon console.

In practice, the surgical robot is used to control endoscopic instruments during surgical procedures. The robot is composed of three elements: a surgeon console (Fig. 1) with an integrated three-dimensional stereoscopic viewer, a patient-side cart comprising robotic arms (Fig. 2) and a vision system (Fig. 3). The surgeon is seated in front of the console and operates instruments by means of the two master controls. The surgeon's head rests between infrared sensors on either side of the viewer providing a magnified three-dimensional stereoscopic view of the operative field. The extremities of the instruments are aligned on the display screen by the master controls to ensure natural and predictable movements of the instruments.

The surgical robot allows real-time and direct control of instrument movements by the surgeon. It uses a kinematic system (based on the principles of articulated movements) allowing the surgeon to use open surgery techniques via the console. These open surgical techniques are instantaneously converted into minimally invasive surgical techniques at the surgical field. The robot provides the surgeon with access to the surgical field via small incisions without compromis-