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BRIEF COMMUNICATION

Evolution of robot-assisted general surgery in Greece and Cyprus

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Abstract
Robot-assisted general surgery in Greece and Cyprus coincided with a devastating financial crisis. We hereby present the evolution of the technology in this unwelcoming environment, using data provided to us by the official distributor of the Da Vinci platform in these countries.

Keywords Robotic surgery · Robot-assisted surgery · Financial crisis · Robotic general surgery

Robot-assisted surgery (RAS) was first described in 1985 and has significantly evolved to its current state in the form of the da Vinci® surgical system (Intuitive Surgical Inc., Sunnyvale, CA, USA). Da Vinci® is currently the only commercially available robotic platform in the market, manufactured solely by Intuitive Surgical Inc., after United States Food and Drug Administration's approval back in 2000 [1]. RAS was developed to increase the dexterity and facility with which complex surgical dissections are performed, to enhance visualization by providing three-dimensional stable view to the surgeon and to overcome limitations of the standard laparoscopic approach such as ergonomics [2, 3]. Another critical advantage of RAS is the shorter learning curve when compared to laparoscopy, while intra-operative blood loss and operative time are believed to decrease as a surgeon's experience grows [4]. On the other hand, disadvantages of the technology are the high-to-acquire cost and the size of the device, making it almost impossible to fit into small operating rooms [5].

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Since its launch, RAS has gained massive support in two specific specialties: urology and gynecology. Indicative of this enthusiasm is the fact that, in 2012, out of almost 500,000 robotic operations worldwide, 350,000 of them have been performed for urological and gynecological indications [6]. This can be credited to the efficacy of the intracorporeal suturing that the robotic platform provides during urological or gynecological operations [7]. Apart from these two specialties, the robotic technology is also used in general, pediatric, thoracic, and cardiac surgery among others [6]. In the case of general surgery, there have been numerous reports of a variety of abdominal operations, including: cholecystectomies, anti-reflux operations, adrenalectomies, colorectal procedures, small bowel resections, pancreas and liver surgery, as well as bariatric operations [3]. Albeit the fact that robotics have been applied to almost all procedures of the general surgery spectrum, the precise role of the technology in this field remains a subject that needs further research no matter the obvious advantages. Until now, limited clinical evidence exists that could establish the use of robotics as the gold standard for the procedures of general surgery. While RAS is still in its infancy with multiple novel systems currently under development and clinical trials in progress, the opportunities for this technology are promising, and robotics should have a lasting impact in the field of general surgery [8].

RAS gradually also gained its position in the Greek healthcare industry. Early after the arrival of the first Da Vinci® platform in the country, a series of robotic radical prostatectomies was published where the authors reported their encouraging results and described the technology as

very promising with a 10–12 cases' learning curve and adequate oncological outcomes [9]. Furthermore, one of the largest series of single-site robotic cholecystectomies was published with the excellent results and no reported complications [10]. More recently, another study reported results from 45 patients who underwent robotic right colectomies with intracorporeal anastomosis for non-metastatic malignancy of the right colon [5]. Despite the size of Greek healthcare system, it is evident that RAS has gained a significant interest throughout the last decade.

According to the data provided to us by Sofmedica Inc., which is the official distributor for Intuitive Surgical Inc. in Greece and Cyprus, during an 11-year period, from January 2007 until November 2017, a total of 13,461 robot-assisted surgical procedures were performed in 8 Greek and 1 Cypriot hospital. At the moment, there are ten active da Vinci platforms used in both countries; all platforms are used in private institutions, while only 1 is used in a public institution. The total annual number of cases increased from 227 in 2007 to 985 in 2011 and to 1950 in 2017. The majority of these procedures (73%, $n=9912$) were performed for urologic cases followed by procedures, which were performed for general surgery cases (18%, $n=2428$) and gynecology cases (7.5%, $n=1020$). More specifically, the different types of general surgery procedures performed per year are shown in Fig. 1. The number of annual cases increased from 21 in 2007 to 231 in 2011 and to 378 in 2017. The most common types of procedures performed were cholecystectomy, splenectomy, appendectomy, and liver cyst deroofing (1024 cases) followed by colorectal resections (472 cases), upper gastrointestinal surgery (436 cases), abdominal wall surgery (285 cases), bariatric surgery (154 cases), hepato-biliary and pancreatic surgery (59 cases), and endocrine surgery (26 cases).

The adoption of RAS procedures in Greece coincided with a rapidly escalating financial crisis. The country has been affected by the fiscal turmoil beginning in 2008 more than any other European Union country [11]. Unemployment, income reduction, and poverty were among the most serious consequences of the crisis, resulting in severe austerity measures which devastated the spending power of the Greek health system [12]. Notwithstanding the crisis, the performance of RAS grew significantly during the years. Nevertheless, the growth in these numbers must be interpreted with caution; most of these procedures were performed in private institutions, and accordingly, one could hypothesize that the economic burden of these procedures was withstood by specific social class patients.

RAS has been received warmly in Greece by both surgeons and patients, despite its higher cost compared to the conventional laparoscopy or traditional open techniques. Although in an unwelcoming and uncertain financial environment, robotic surgical technology made its debut successfully and recorded a steady increase in the number of procedures performed throughout the years. Although not yet extensively used in the public healthcare sector,

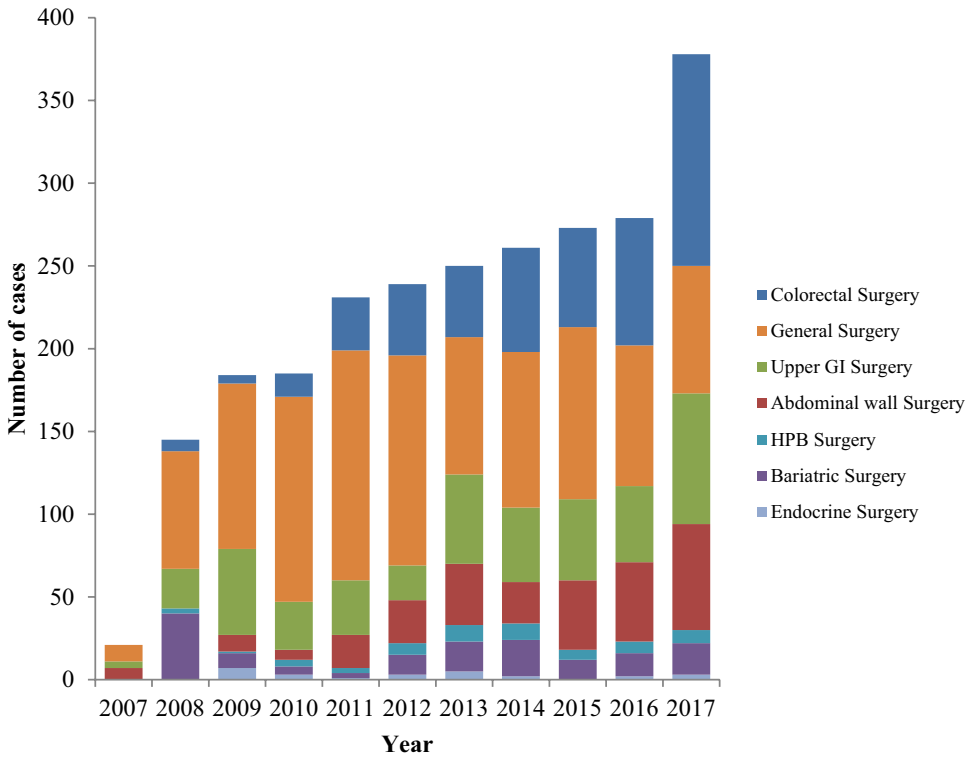

Fig. 1 General surgery robotic-assisted procedures performed annually in Greece and Cyprus (2007–2017)

its steady adoption and reported encouraging results will embolden patients and surgeons to its wider use in the context of future economic regrowth. With more platforms soon to enter the market, the costs to acquire the technology and to perform maintenance and the price of intra-operative disposable instruments are believed to decrease. Therefore, cost-efficiency of RAS should be the next outcome to get researched thoroughly, after more platforms become commercially available.

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Compliance with ethical standards

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of interest Konstantinos Konstantinidis is a teaching proctor for Intuitive Surgical. Argyrios Ioannidis, Nikolaos Machairas, Christos Koutserimpas, Eleftherios Spartalis, and Michael Konstantinidis declare no conflict of interest.

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