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Robotic Single-Site Surgery: A Summary of the Current Clinical Experience

Jose E. Escobar Dominguez[1] · **Anthony M. Gonzalez**[1,2]

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Abstract The robotic single-site platform was released in late 2011 and since then it has been applied in the fields of gynecologic surgery and general surgery. In this review, we include the reported robotic experience in the above-described fields using this platform to perform surgery as well as its advantages and limitations.

Keywords Robotic surgery · Single site surgery · Minimally invasive surgery · daVinci single-site robotic platform

Introduction

Over the past three decades, the advances in minimally invasive surgery have evolved from the simplest surgical techniques to the more advanced instrumentations and devices. The idea of offering single-access minimally invasive procedures led to the creation of varied instruments, ports, and trocars. Despite these efforts, several challenges such as collision of instruments, poor ergonomics, lack of triangulation, and difficulty in manipulation of the anatomical structures were noticed [1].

In an attempt to take advantage of the features of robotic surgery, the initial experience on single-incision robotic surgery consisted in placing a Gelport (*GelPort; Applied Medical, Rancho Santa Margarita, CA*) and crossing the trocars at the fascial level to achieve triangulation [2]. As with laparoscopic surgery, this practice led to difficulty in maneuvering the instruments and even collisions. Further efforts to minimize or eliminate these issues would lead to the development of the daVinci Single-Site robotic platform (Intuitive Surgical Inc., Sunnyvale CA) released in late 2011 [3]. Since its introduction, it has been applied in several surgical scenarios. In this article, we describe the worldwide experience of robotic single-site surgery.

Robotic Single-Site Platform

The Single-Site Platform was created for the daVinci Si system, and consists of a silicon port, curved cannulas for instrumentation, and a straight trocar for the assistant and various instruments. The silicone port has four openings: two for curved robotic cannulas, one opening for the camera trocar, and the last one for the assistant trocar. Its curved cannulas, once placed through the silicone port, resided crossed at the level of the patient's fascia. These curved trocars allow flexible instruments to cross in order to achieve triangulation (Fig. 1). Subsequently, the software at the console reassigns instrumentation so that the instrument on the right of the screen is controlled by the surgeon's right hand and vice versa. This allows collisions to be avoided and affords the surgeon the most comfort. [3].

Robotic Single Site in Gynecologic Procedures

The use of this platform has been widely described in hysterectomy showing similar and comparable results to the single-incision laparoscopic counterpart [4], but with

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✉ Anthony M. Gonzalez
AnthonyG@baptisthealth.net

[1] Baptist Health Medical Group, Baptist Hospital of Miami, Bariatric Surgery, Baptist Health South Florida, Miami, USA

[2] FIU College of Medicine, Miami, USA

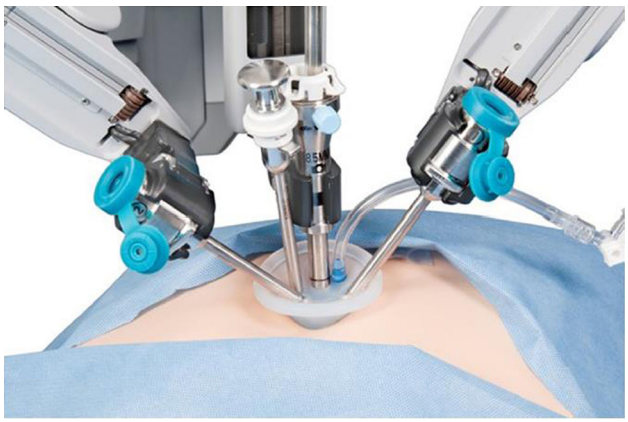

Fig. 1 Port placement and docking (reproduced with permission from Intuitive Surgical Inc.)

longer surgical times [4, 5]. Difficulty in suturing the vaginal cuff has been reported with this approach at the beginning of the learning curve [6], but a retrospective review reported by Akdemir et al. has demonstrated that after 14 cases the surgeon becomes proficient in suturing the vaginal cuff [7]. Furthermore, it seems that there is a linear correlation between vaginal cuff closure time, console time, and operating time with the number of cases performed [6]. On the other hand, single-site robotic hysterectomy has been reported to be a safe and effective procedure that is not influenced either by body mass index (BMI) or by uterine size [8, 9].

The experience in single-site robotic gynecologic surgery is not just limited to hysterectomy. A wide variety of gynecological procedures have been performed utilizing this approach, including myomectomies [10, 11], adnexal surgery [12] sentinel lymph node mapping, and pelvic lymphadenectomy for staging of cancer [13, 14].

Robotic Single Site in Urology

Urology is the area where the most robotic experience lies. Furthermore, several procedures have been performed by urologists using wristed instruments prior to the release of the da Vinci Single-Site system [15–19]. Both partial and radical nephrectomies have been performed with the da Vinci Single-Site platform in small case series [20, 21]. However, feasibility and safety of the procedures with this platform still needs to be determined.

Robotic Single Site in General Surgery

In general surgery, the single-site platform has the FDA approval exclusively for performing cholecystectomies. The initial experience with robotic single-site cholecystectomy was reported in late 2011 by Wren [3] and Kroh [22]. Subsequently, several case series have reported feasibility and safety of the procedure [23–29] even in acute and complex cases [30].

At the time of this review, the largest experience on robotic Single-Site cholecystectomy has been reported by our group in *"A multicenter study of initial experience with single-incision robotic cholecystectomies (SIRC) demonstrating a high success rate in 465 cases"* [31]. This multisurgeon multicenter experience reported a 97.8 % success rate and included a wide variety of clinical scenarios like obesity, previous abdominal surgery, acute cholecystitis, and ASA 3 or greater. In this report, predictors of conversion to multiport robotic or conventional laparoscopic surgery included male gender and acute cholecystitis or biliary colic at the time of surgery.

The addition of fluorescent cholangiography has been helpful during robotic cholecystectomy with the use of Indocyanine green (ICG) with the Firefly® technology [32–35]. The use of ICG is not exclusive of the robotic approach since it has been also applied in conventional laparoscopic surgery [36]. Application of this technology consists in injecting the ICG preoperatively since hepatic clearance takes approximately 40 min to be excreted to the bile ducts. During surgery, when the substance is stimulated with a near infrared beam, it becomes fluorescent. The largest case series reported on intraoperative fluorescent cholangiography has been reported by Dakasaki et al. [34] in which the cystic duct, the common bile duct, and the common hepatic duct were successfully visualized with ICG in 97.8, 96.1, and 94 % of the cases, respectively. Docking time is an important point of debate in robotic surgery since it has been claimed that it increases room time; however, Iranmanesh et al. [37] reported a case series on robotic single-site cholecystectomy analyzing docking time. They found that as the learning curve progresses and the surgical team becomes more proficient, in their case series overall docking time represented just 8 % of the total surgical time. Our experience demonstrated that after the completion of 20 cases, the total duration for incision, port placement, and docking was reduced to 6–8 min.

The vast experience of this author (AMG) of over 500 robotic single-site cholecystectomies in all patient types and disease states has led to some lessons being learned. Robotic surgery, in general, yields the best results in cases of bigger patients, whereas some challenges occur when the patient is too small. The trocars extend over the liver edge and prohibit dissection. If this is noticed at the commencement of the surgery, the incision can be placed infraumbilical and hence "separating" the setup from the gallbladder. Previous abdominal surgery and intra-abdominal adhesions can be dealt with laparoscopically prior to docking the robot. Patients with acute cholecystitis can

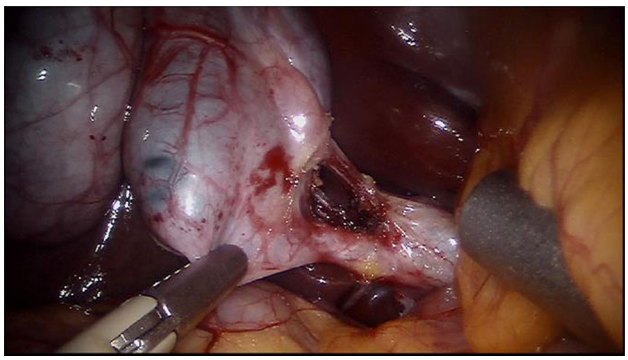

Fig. 2 Dissection of the triangle of Calot during robotic single-site cholecystectomy

have their gallbladders decompressed prior to grasping by assistant, which will facilitate dissection. In addition, these patients also can have their dissection of the triangle of Calot by suction, hook cautery, or Maryland dissector (Fig. 2). As a last resort, if the single-site platform does not facilitate cholecystectomy, conversion to a multiport robotic cholecystectomy is always possible.

Conclusions

In conclusion, Robotic Single-Site surgery has been applied in different clinical scenarios by different surgical specialties proving to be a safe and effective approach. However, since clear benefit has been difficult to demonstrate, this surgical platform is only approved for specific procedures. As technology progresses, further enhancements of this platform will allow advantages to be realized. If this occurs, then more procedures can be performed with the single-site platform with a clear advantage.

Compliance with Ethics Guidelines

Conflict of Interest Drs. Escobar Dominguez and Gonzalez declare no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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