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REVIEW

Robotic-assisted right colectomy. Official expert recommendations delivered under the aegis of the French Association of Surgery (AFC)



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KEYWORDS

Surgery by robotic approach;
Minimally invasive surgery;
Right colectomy;
Oncological colonic resection;
Recommendations

Summary Twenty-seven experts under the aegis of the French Association of Surgery (AFC) offer this reference system with formalized recommendations concerning the performance of right colectomy by robotic approach (RRC). For RRC, experts suggest patient installation in the so-called "classic" or "suprapubic" setup. For patients undergoing right colectomy for a benign pathology or cancer, RRC provides no significant benefit in terms of intra-operative blood loss, intra-operative complications or conversion rate to laparotomy compared to laparoscopy. At the same time, RRC is associated with significantly longer operating times. Data from the literature are insufficient to define whether the robot facilitates the performance of an intra-abdominal anastomosis, but the robotic approach is more frequently associated with an intra-abdominal anastomosis than the laparoscopic approach. Experts also suggest that RRC offers a benefit in terms of post-operative morbidity compared to right colectomy by laparotomy. No benefit is retained in terms of mortality, duration of hospital stay, histological results, overall survival or disease-free survival in RRC performed for cancer. In addition, RRC should not be performed based on the cost/benefit ratio, since RRC is associated with significantly higher costs than laparoscopy and laparotomy. Future research in the field of RRC should consider the evaluation of patient-targeted parameters such as pain or quality of life and the technical advantages of the robot for complex procedural steps, as well as surgical and oncological results. © 2022 Elsevier Masson SAS. All rights reserved.

Introduction

Right colectomy is one of the most frequent procedures to treat benign and malignant pathologies of the cecum, right colon, and hepatic flexure [1,2]. Laparoscopy is considered the standard minimally invasive approach [3], but the use of robotic surgery is increasing [4]. In recent years, a growing number of healthcare establishments have equipped themselves with one or more robotic platforms and these are seeing increasing use in the field of digestive surgery [5].

Robotic right colectomy (RRC) is the ideal procedure for developing a robotic colorectal surgery program, and should be mastered initially before proceeding to perform more complex procedures, such as low anterior resection of the rectum with complete mesorectal excision [6]. Scientific publications concerning RRC are steadily increasing but, to date, only one randomized clinical trial comparing

laparoscopy vs. RRC has been published [7,8]. The current literature concerning RRC consists largely of retrospective studies with a low level of evidence.

However, we felt it was important to propose this reference system under the aegis of the French Association of Surgery (AFC), to answer current relevant questions concerning RRC including technical aspects as well as post-operative results and long-term results.

Methods

These recommendations are the result of the work of a group of experts convened by the AFC and they are presented according to the model defined in the AFC standard of formalized expert recommendations [9]. First, the

Table 1 List of technical notes and questions that form the basis for formal recommendations by experts on robotic right colectomy (RRC).

Question 1 (Technical Note)	For RRC, what is the recommended setup regarding the positioning of the trocars, the docking of the robot, and the preparation of the instruments necessary for the procedure?
Experts	R. Lupinacci, P. Rouanet, A. Valverde
Question 2 (Technical Note)	What are the steps of RRC?
Experts	R. Lupinacci, E. Cotte, G. Manceau
Question 3 (Technical Note)	What training/experience should the surgeon have before performing RRC? Is the learning curve for RRC shorter compared to the learning curve for laparoscopic right colectomy?
Experts	R. Lupinacci, B. Lelong, D. Pezet, N. de'Angelis, A. Beliard, Z. Lakkis
Question 4 (PICO)	Does the performance of RRC in a patient with benign or malignant disease of the right colon bring benefits in terms of blood loss and intra-operative complications compared to a laparoscopic or open right colectomy?
Experts	R. Lupinacci, Q. Denost, N. Goasguen
Question 5 (PICO)	Does the performance of RRC in a patient with benign or malignant right colon pathology bring any benefit in terms of operative time compared to a laparoscopic or open right colectomy?
Experts	R. Lupinacci, G. Manceau, C. Perrenot
Question 6 (PICO)	Does the performance of a RRC in a patient with benign or malignant pathology the right colon bring any benefit in terms of conversion rate compared to a laparoscopic right colectomy?
Experts	R. Lupinacci, Z. Lakkis, G. Meurette
Question 7 (PICO)	For performance of RRC in a patient having benign or malignant pathology of the right colon, does the robotic approach facilitate the realization of an intra-abdominal anastomosis compared to a laparoscopic right colectomy?
Experts	P. Genova, N. de'Angelis, G. Meurette
Question 8 (PICO)	Does the realization of RRC in a patient with a resectable adenocarcinoma of the right colon, facilitate lymphadenectomy with complete mesocolic resection compared to a laparoscopic right colectomy?
Experts	P. Genova, Q. Denost, G. Manceau
Question 9 (PICO)	Does the performance of RRC in a patient with benign or malignant pathology of the right colon, bring any benefit in terms of post-operative morbidity and mortality compared to a laparoscopic or open right colectomy?
Experts	P. Genova, B. Lelong, A. Valverde
Question 10 (PICO)	Does the performance of RRC in a patient with benign or malignant pathology of the right colon, bring any benefit in terms of duration of hospital stay compared to a laparoscopic right colectomy?
Experts	S. Abdalla, E. Cotte, P. Rouanet
Question 11 (PICO)	Does performing a RRC in a patient with resectable right colon adenocarcinoma provide any benefit in terms of overall survival and recurrence-free survival compared to laparoscopic or open right colectomy?
Experts	S. Abdalla, R. Lupinacci, G. Meurette
Question 12 (PICO)	Does performing RRC in a patient with resectable right colon adenocarcinoma provide any benefit in terms of histological results (e.g. R0 resection) compared to laparoscopic or open right colectomy?
Experts	S. Abdalla, N. Goasguen, Z. Lakkis
Question 13 (PICO)	Is the realization of RRC in an elderly patient (> 70 years old) with a benign or malignant pathology of the right colon feasible and does it bring benefits compared to right colectomy by laparoscopic or open approach?
Experts	N. de'Angelis, A. Beliard, P. Genova
Question 14 (PICO)	Does performing RRC provide an advantage in terms of patient satisfaction (e.g. pain, cosmetic result, quality of life) compared to laparoscopic or open right colectomy?
Experts	N. de'Angelis, S. Abdalla, E. Cotte
Question 15 (PICO)	Does the performance of RRC provide an economic advantage (cost/benefit ratio) compared to a laparoscopic or open right colectomy?
Experts	N. de'Angelis, S. Abdalla, C. Perrenot
Question 16	Based on the evaluation of the available literature, what types of studies and research should be encouraged in the field of robotic surgery for benign or malignant pathologies of the right colon?
Experts	N. de'Angelis, B. Lelong, D. Pezet

RRC: robotic right colectomy.

Table 2 Recommendations according to the GRADE method.

Level of evidence: high	GRADE 1+	Strongly positive recommendation	“must be done...”
Level of evidence: moderate	GRADE 1–	Strongly negative recommendation	“must not be done...”
Insufficient level of evidence	GRADE 2+	Positive but optional recommendation	“must probably be done...”
	GRADE 2–	Negative but optional recommendation	“should probably not be done...”
	Expert opinion	Recommendation in the form of expert advice	“Experts suggest...”

project coordinators (NdeA and RML) defined a list of questions (three technical notes and 13 questions). These were validated by the organizing committee (PP, SG and CG). These questions were formulated according to the PICO format [10], which defines the patient population, the type of intervention, the comparison and the outcome considered. Thus, the 16 experts who were charged with writing the answers to the questions were contacted and informed of the instructions for formulating the recommendations. For each question, the experts (Table 1) had to respond with a short discussion based on an evaluation of the literature and then to formulate one or more recommendations. The recommendations had to be formulated according to the GRADE methodology (Grade of Recommendation Assessment, Development and Evaluation)[11], in order to define the level of evidence of the bibliographic references supporting each recommendation (Table 2). A review committee consisting of 11 experts then independently reviewed the written responses of the expert panel. Reviewers were responsible for evaluating the response to each question. Then, in accordance with the Delphi methodology and using the Google Forms online platform, the experts expressed an individual rating for each recommendation using a scale ranging from 1 (completely disagree) to 9 (completely agree) [9]. In order to receive a strong recommendation, at least 70% of the experts had to have an opinion that generally concurred with the initial recommendation. If such strong agreement could not be obtained, the recommendations were reformulated and, again submitted for rating with the aim of reaching a consensus. Only the expert opinions that obtained strong agreement were retained.

Field 1. Questions regarding the technique

Question 1: For RRC, what is the recommended setup regarding the positioning of the trocars, the docking of the robot, and the preparation of the instruments necessary for the procedure?

Recommendation

- There are insufficient data to recommend a specific installation (docking and positioning of trocars). Experts suggest that the so-called “classic” installation is reproducible and safe. Suprapubic positioning can be useful for tumors located at the level of the right colonic angle or in the proximal transverse colon and/or when a D3 lymphadenectomy is planned.

(Expert opinion). Level of agreement: 96.3%.
(See Argument of Technical Note 1 in the supplement).

Question 2: What are the steps of RRC?

Recommendations

- Data in the literature are insufficient to recommend a specific operative technique. Experts suggest favoring the medial approach with identification of the ileo-colic vessels, then right colic and middle colic vessels. Experts suggest dividing the vessels at their origin with exposure of the anterior surface of the superior mesenteric vein, visualization of the third portion of the duodenum and the anterior surface of the uncinate process. For hemostasis, the use of plastic or metal clips seems safe and easy, but thermofusion can also be an option (Expert advice). Level of agreement: 92.6%
- Concerning whether an extra- or intra-abdominal anastomosis should be performed, recent data in the literature seem to favor intra-abdominal anastomosis, particularly to limit the length of the incision and to favor prompt resumption of intestinal transit. Nevertheless, the quality and the number of available studies cannot conclude regarding the superiority of the intra-abdominal anastomosis vs. extra-abdominal anastomosis.

(Expert opinion). Level of agreement: 88.8%.

- Experts suggest that data in the literature are insufficient to support the use of indocyanine green angiography during right colectomy or to recommend its routine use.

(Expert opinion). Level of agreement: 96.3%.
(See Argument of Technical Note 2 in supplement).

Question 3: What training/experience should the surgeon have before performing RRC? Is the learning curve for RRC shorter compared to the learning curve for laparoscopic right colectomy?

Recommendations

- Robotic surgery should be evaluated in comparison to laparoscopy. In this context, the teaching of RRC must ensure patient safety, both in the short term (complications) and in the long term (carcinological quality of the resection). Learning the technique of RRC must take place in a suitable environment and with the supervision of a surgeon experienced in minimally invasive oncological colorectal surgery. Rigorous analysis of the results at each stage of a surgeon’s skill acquisition must be the rule throughout the learning period. The division of the intervention into three segmental modules (vascular control and lymph node dissection, colonic mobilization, anastomosis) contributes to the standardization of the procedure and facilitates the evaluation of acquisitions.

(Expert opinion). Level of agreement: 88.8%.

- Experts suggest that the learning curve for RRC is faster than for laparoscopic right colectomy. The acquisition of skills in laparoscopy and robotics for young surgeons during initial training should be encouraged.

(Expert opinion). Level of agreement: 88.8%.

(See Argument of Technical Note 3 in supplement).

Field 2. Intra-operative results

Question 4: Does the performance of RRC in a patient with benign or malignant disease of the right colon bring a benefit in terms of blood loss and intra-operative complications compared to laparoscopic or open right colectomy?

Recommendations

- RRC does not provide any significant benefit in terms of intra-operative blood loss compared to laparoscopic or open right colectomy.

(Grade 2–). Level of agreement: 100%.

- RRC does not provide any significant benefit in terms of intra-operative complications compared to laparoscopic or open right colectomy

(Grade 2–). Level of agreement: 96.3%.

Discussion

The intra-operative complications of right colectomies *via* a minimally invasive approach (laparoscopy or robotic) are poorly described in published studies [7,8,12–19]. The randomized controlled study by Park et al. did not show any statistically significant difference in blood loss between the two surgical approaches (35.8 ± 26.3 mL for RRC vs. 56.8 ± 31.3 mL for laparoscopy; $P=0.211$) [7]. Similar results were observed in a large Italian multicenter study (50 ml (50–50) for RRC vs. 50 mL (50–75) for laparoscopy; $P=0.876$) [18], while the results of five other studies are in favor of the robotic route [12–14,17,19]. Finally, the results of two recent meta-analyses are contradictory [15,20]. Genova et al. [15] found an advantage in terms of blood loss for the robotic approach compared to laparoscopy (mean difference: –12.14 mL [5.2–19.08]; $P=0.0006$; $I^2: 18\%$), while Rausa et al. [20] found an advantage of the robotic approach compared with the open approach (Relative Risk: 42; 95% confidence interval: 10–72), but no statistically significant advantage compared with the laparoscopic approach.

Question 5: Does the performance of RRC in a patient with benign or malignant right colon pathology, bring a benefit in terms of operative time compared to a laparoscopic or open right colectomy?

Recommendation

- RRC is associated with a significantly longer operative time than right colectomy by laparoscopic or open approach

(Grade: 1+). Level of agreement: 85.2%.

Discussion

In most studies [7,18], the robotic approach is associated with an increase in operative time compared not only to the open approach, but also compared to the laparoscopic approach. In their randomized study that included a small number of patients (35 patients in each group) [7], Park et al. found a > 60 minute increase in operative time for the robotic approach. In the study by Solaini et al. [18] that included 389 patients, the robotic approach was associated with a significant increase (+90 min) in the median operating time. This result was confirmed in a meta-analysis published in 2020 [15], where the operating time was longer with the robotic approach compared to laparoscopy regardless of the type of anastomosis performed (+ 43 min in the case of extra-abdominal anastomosis and + 67 min in case of intra-abdominal anastomosis).

Question 6: Does the performance of RRC in a patient with benign or malignant pathology the right colon offer benefits in terms of conversion rate compared to a laparoscopic right colectomy?

Recommendation

- RRC does not provide any benefit in terms of conversion rate to laparotomy compared to laparoscopic colectomy

(Grade: 2–). Level of agreement: 88.8%.

Discussion

In their randomized clinical trial, Park et al. [7] found a conversion rate to laparotomy of 0% in both groups. Based on the systematic reviews and meta-analyses published to date, conversion rates to laparotomy vary from 3.2% to 5.6% for the laparoscopic route and from 2.3% to 4.1% for the robotic route with, in most cases, non-statistically significant differences between the robotic and laparoscopic route [15,20–24].

Question 7: For performance of RRC in a patient having benign or malignant pathology of the right colon, does the robotic approach facilitate the realization of an intra-abdominal anastomosis compared to a laparoscopic right colectomy?

Recommendation

- Experts suggest that the data in the literature are insufficient to define whether the robot facilitates the performance of an intra-abdominal anastomosis during a right colectomy compared to laparoscopy. However, the robotic approach is more frequently associated with an intra-abdominal anastomosis than the laparoscopic approach.

(Expert opinion). Level of agreement: 96.3%.

Discussion

The meta-analysis by Geneva et al. [15] found that performance of an intra-abdominal anastomosis was ten times more frequent during robotic than laparoscopic procedures. These data suggest a tendency in robotic surgery to routinely perform intra-abdominal anastomosis, but they are insufficient to conclude on the technical ease of performance nor its effectiveness in relation to the rate of anastomotic leaks. To date, retrospective comparative studies that have reported the percentage of anastomotic leaks after intra-abdominal anastomosis performed during robotic or laparoscopic surgery have not revealed any significant difference between the two surgical approaches [25–31]. Individual experience and the learning curve of the operators were not evaluated, but could represent a bias in these retrospective studies.

Question 8: Does the realization of RRC in a patient with a resectable adenocarcinoma of the right colon, facilitate lymphadenectomy with complete mesocolic resection compared to a laparoscopic right colectomy?

Recommendation

- Experts suggest that performing complete mesocolic excision associated with central vascular ligation according to the technical standards described for adequate lymphadenectomy is feasible by robotic surgery as well as by laparoscopy

(Expert opinion). Level of agreement: 81.4%.

Discussion

Complete mesocolic (CME) in association with central vascular ligation (CVL) was proposed in 2009 [32]; many consider it to be superior to standard right colectomy [32,33] due to a reduced risk of recurrence and improved survival [34,35]. However, this technique remains controversial and its use is not widespread [36].

Spinoglio et al. [30] reported the largest series with 202 patients (101 laparoscopic CME and 101 robotic CME), operated by the same surgeon between 2005 and 2013. The authors found no statistically significant differences in terms of resumption of transit, duration of hospitalization, post-operative morbidity, number of lymph nodes removed, and long-term oncological results. Operative time was significantly longer in the robot group (279 ± 80 min vs. 236 ± 68 min, $P < 0.001$), but the conversion rate was lower (0 vs. 7%, $P = 0.01$). The two-center study by Ceccarelli et al. [37] included 40 patients matched by propensity score (20 robotic surgeries and 20 laparoscopies with use of 3-D vision). The only difference between the two groups was the statistically significantly longer operative time in case of robotic surgery (225.2 ± 73.0 min vs. 165.9 ± 30.2 min, $P = 0.002$). The authors concluded that due to the higher cost and the longer operating time with the robot, laparoscopy with 3-D vision could be considered a reliable alternative for performing right colectomy with CME. Yozgatli et al. [38] analyzed 96 patients, 35 of whom were operated on robotically. Operative time was statistically significantly longer in the robotic group (286 ± 77 vs. 132 ± 40 min, $P = 0.0001$), with no difference in conversion rate or post-operative morbidity compared to laparoscopy. Histologically, the robotic

approach made it possible to obtain a statistically significantly longer colon-vascular ligature distance (13 ± 3.5 vs. 11 ± 3 cm; $P = 0.02$), and retrieved statistically significantly more lymph nodes in the operative specimen (41 ± 12 vs. 33 ± 10 ; $P = 0.04$).

Field 3. Post-operative results

Question 9: Does the performance of RRC in a patient with benign or malignant pathology of the right colon, bring any benefit in terms of post-operative morbidity and mortality compared to a laparoscopic or open right colectomy?

Recommendations

Experts suggest that performing RRC in a patient with benign or malignant pathology of the right colon:

- provides a benefit in terms of morbidity compared to open right colectomy but not compared to laparoscopy
(Expert opinion). Level of agreement: 100%.
- Does not provide any benefit in terms of post-operative mortality compared to right colectomy by open approach or laparoscopy

(Expert opinion). Level of agreement: 92.6%.

Discussion

In a recent meta-analysis [15] including 24,193 patients (21,397 (88.4%) operated by laparoscopy and 2,796 (11.6%) by robot), the rate of overall post-operative complications was higher in the laparoscopy group than in the robot group (Odds Ratio (OR): 1.19 [95% CI: 1.03–1.38]; $P = 0.02$; $I^2 = 0\%$), although no statistically significant differences were noted in the rates of severe post-operative complications (Dindo-Clavien \geq III) (OR: 1.09 [95% CI: 0.82–1.47]; $P = 0.55$; $I^2 = 0\%$), anastomotic leak (OR: 1.18 [95% CI: 0.73–1.90]; $P = 0.5$; $I^2 = 0\%$), ileus (OR: 1.05 [95% CI: 0.79–1.39]; $P = 0.73$; $I^2 = 5\%$), or surgical site infection (OR: 1.17 [95% CI: 0.9–1.51]; $P = 0.24$; $I^2 = 0\%$). Other meta-analyses found contradictory conclusions regarding post-operative morbidity [39–41], but all agree that the post-right colectomy mortality rates were comparable between robotic and laparoscopic procedures (ranging from 0% to 1.15% for RRC and from 0% to 0.33% for laparoscopy) [15,39–41].

The few studies that compared RRC vs. laparoscopy vs. open approach [42–44] found a trend towards higher post-operative morbidity for the laparotomy group (up to 21%) compared to the laparoscopy (7%) and robot (10%) groups, but the mortality rate still appears comparable (estimated between 0% and 1.5%).

Question 10: Does the performance of RRC in a patient with benign or malignant pathology of the right colon, offer any benefit in terms of duration of hospital stay compared to a laparoscopic right colectomy?

Recommendation

- Performing RRC in a patient with benign or malignant pathology of the right colon does not provide any

benefit in terms of duration of hospital stay compared to a laparoscopic right colectomy.

(Grade 2–). Level of agreement: 81.4%.

Discussion

In their randomized trial Park et al. [7] did not find any statistically significant difference between the two surgical approaches for the duration of hospital stay (7.9 ± 4.1 days for RRC vs. 8.3 ± 4.2 days for laparoscopy; $P=0.130$). Based on the available meta-analyses, the robotic approach was sometimes associated with a shorter hospital stay [42,45], independent of the type of anastomosis, but this was not found in all studies [20,22–24]. In the meta-analysis by Rausa et al. [20], RRC was also associated with a shorter hospital stay compared to open right colectomy.

Five clinical trials comparing RRC vs. laparoscopy are currently in progress (from clinicaltrial.gov) and all consider the duration of hospitalization as the primary or secondary endpoint. The results of these tests should make it possible to better answer the question.

Question 11: Does performing a RRC in a patient with resectable right colon adenocarcinoma provide any benefit in terms of overall survival and recurrence-free survival compared to laparoscopic or open right colectomy?

Recommendation

- Experts suggest that performing RRC in a patient with resectable right colon adenocarcinoma does not provide benefits in terms of overall survival and recurrence-free survival compared to laparoscopic or open right colectomy

(Expert opinion). Level of agreement: 96.3%.

Discussion

Based on the randomized trial by Park et al. [7], the 5-year oncological results were not statistically significantly different between the robotic and laparoscopic approach in terms of overall survival (91.1% for the RRC group vs. 91% for the laparoscopy group, $P=0.678$) and recurrence-free survival (77.4% for the RRC group vs. 83.6% for the laparoscopy group, $P=0.442$) [8]. Other retrospective studies confirm the absence of statistically significant differences for disease-free survival and overall survival at five years between the robotic route and the laparoscopic route [16,30] or the open route [43].

Question 12: Does performing RRC in a patient with resectable right colon adenocarcinoma provide any benefit in terms of histological results (e.g., R0 resection) compared to laparoscopic or open right colectomy?

Recommendation

- Experts suggest that performing RRC in a patient with a resectable right colon adenocarcinoma does not provide

any benefit in terms of histological results, such as R0 resection or the number of lymph nodes removed, compared to a laparoscopic or open right colectomy

(Expert opinion). Level of agreement: 96.3%.

Discussion

According to the randomized trial by Park et al. [7], there was no statistically significant difference found between robotic and laparoscopic right colectomy for the number of lymph nodes removed (29.9 ± 14.7 vs. 30.8 ± 13.3 , $P=0.265$) or for the length of the proximal margin (18.6 ± 7.3 cm vs. 18.3 ± 9.9 cm, $P=0.384$) and distal margin (18.0 ± 9.0 cm vs. 14.5 ± 8.0 cm, $P=0.090$). The most recent meta-analysis found a statistically significantly higher number of lymph nodes removed by robotic means [15], whereas this result was not statistically significant in the previous meta-analyses [20,23,24].

Field 4. Prospects for future application and research

Question 13: Is the realization of RRC in an elderly patient (> 70 years old) with a benign or malignant pathology of the right colon feasible and does it provide benefits compared to right colectomy by laparoscopic or open approach?

Recommendation

- Experts suggest that for patients aged 70 or over, RRC is an option after careful evaluation of the patient's medical history and co-morbidities as well as cost-effectiveness. The expected short- and long-term results are similar to those observed for younger patients and there are potential advantages over colectomy *via* open laparotomy.

(Expert opinion). Level of agreement: 88.8%.

Discussion

Colorectal cancer occurs frequently in elderly patients [46]. The minimally invasive robotic approach is less well-described in this population of fragile patients but would seem to be associated with operative and oncological results similar to laparoscopic right colectomy [2], compared with those observed in younger patients [2,47]. To date, robotic surgery can be considered a safe and feasible option in elderly patients, but the presence of co-morbidities (evaluated using the Charlson score) must be considered in relation to longer operating times (and therefore the time of anesthesia) of the RRC. This, along with higher costs, imposes the need for a careful evaluation of the surgical indication and careful patient selection in order to propose an adapted personalized treatment.

Question 14: Does performing RRC provide an advantage in terms of patient satisfaction (e.g. pain, cosmetic result, quality of life) compared to laparoscopic or open right colectomy?

Recommendation

- Experts suggest that there is insufficient evidence to establish whether robotic surgery is associated with decreased post-operative pain compared to laparotomy or laparoscopic surgery. This also applies to other patient-centered parameters, such as cosmetic outcome and quality of life after right colectomy.

(Expert advice). Level of agreement: 92.6%.

Discussion

Very few studies have assessed patient-reported outcome measures (PROMs), such as post-operative pain, patient preferences and satisfaction, or post-operative quality of life. Park et al. [7] did not observe any statistically significant differences in terms of post-operative pain intensity assessed on a visual analogue scale (VAS) at D+1 or D+5. Similar results were reported by Guerrieri et al. [48], while a more recent retrospective study found that patients operated on by RRC had less post-operative pain, assessed by VAS at D+1, than patients operated on by laparoscopy [49].

Question 15: Does the performance of RRC provide any economic benefit (cost/benefit ratio) compared to a laparoscopic or open right colectomy?

Recommendation

- The performance of RRC does not bring any advantage in terms of cost-effectiveness compared to a laparoscopic or open right colectomy. Decision to perform RRC should not be made based on the cost/benefit ratio.

(Grade 1–). Level of agreement: 88.8%.

Discussion

Data from the literature agree on the fact that robotic surgery in general, and RRC specifically, are marked by a significant additional cost compared to laparoscopic surgery [15]. Merola et al. [50] evaluated the costs of oncological right colectomy with intra-abdominal anastomosis performed by robotic vs. laparoscopic approach in a retrospective multicenter study. Cost differential analysis revealed that the total costs of the robotic approach (including operating room occupancy costs, surgical instrument costs, and duration of hospital stay) were almost double those of the laparoscopic approach [50]. Expenditure paid by patients and/or healthcare systems may differ from one country to another depending on whether surgery is performed on a public or private service and on the insurance and reimbursement systems, but these results suggest an unfavorable cost-effectiveness ratio for the use of the robot for right colectomy [50]. In addition, there is a lack of medico-economic studies aimed at evaluating the profitability of the robot that take into account specific variables, such as the cost of purchasing the robotic platform, annual

maintenance, and additional costs related to longer operating times or nursing staff training. Likewise, these studies must be constantly updated based on price fluctuations in the marketplace and due to the wider diffusion of robotic systems or the introduction of new technical platforms.

Question 16: Based on the evaluation of the available literature, what types of future studies and research should be encouraged in the field of robotic surgery for benign or malignant pathologies of the right colon?

Recommendations

Experts suggest that clinical research in the field of RRC should be oriented towards the following themes:

- evaluation of the technical advantages of the robot vs. laparoscopy, particularly for performing an intra-abdominal ileocolic anastomosis.
- evaluation of patient centered parameters (e.g., PROMS) or successful patient-oriented surgical outcomes), including post-operative pain, patient satisfaction and quality of life after RRC vs. other surgical approaches.
- evaluation of the cost/effectiveness ratio with judgment criteria adapted to the different scenarios in different countries (e.g., availability of the robot, patient volume, reimbursement system).
- evaluation of the preferences of the operating surgeon from the standpoint of learning the surgical technique, performing complex steps, feelings in terms of stress and operating comfort, and how well the robotic platform and instruments perform in compliance with surgical and/or oncological principles.

Level of agreement: 96.3%.

To assess these objectives, experts suggest carrying out controlled randomized clinical trials or with cluster randomization, specific micro-economic studies and prospective cohort studies. Recognizing the set-up difficulties and the time required to carry out prospective studies, the experts emphasize the interest of multicenter retrospective studies including a large number of patients and using methods to control confounding factors such as propensity score matching.

Level of agreement: 92.6%.

Conclusion

The robotic approach for colorectal surgery is a subject of interest and debate in the literature. We offer here a reference system with formal recommendations from experts concerning the performance of RRC, based on currently available evidence. To date, only a limited number of strong recommendations can be made because of the quality of the studies on RRC. The majority of the recommendations are presented in the form of expert opinions. However, this standard can represent a clinical support for the surgeon in therapeutic decision-making for the patient who requires a right colectomy. In addition, it emphasizes the importance of training young surgeons in minimally invasive surgery, the need to provide information and education to patients who are candidates for such surgery, and the need for studies to support its application.

Notes

a. Experts recognize a strong commercial sponsorship impact on studies concerning robotic surgery that may result in potential publication bias.

b. All experts and reviewers who took part in these recommendations have provided a declaration of interests to ensure the objectivity and transparency of the work.

c. These recommendations are intended as expert advice without medico-legal value.

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PP reports consulting fees from 3M and Integra and owns stock in Virtualisurg.

NdeA, RML, SA, PG, AB, QD, NG, BL, GMa, GMe, CP, DP, SA, DM, SDS, CdeC, EEB, SG, MGR, CG, MK declare that they have competing interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.jviscsurg.2022.04.001>.

References

- [1] de'Angelis N, Lizzi V, Azoulay D, Brunetti F. Robotic versus laparoscopic right colectomy for colon cancer: analysis of the initial simultaneous learning curve of a surgical fellow. *J Laparoendosc Adv Surg Tech A* 2016;26:882–92.
- [2] de'Angelis N, Abdalla S, Bianchi G, et al. Robotic versus laparoscopic colorectal cancer surgery in elderly patients: a propensity score match analysis. *J Laparoendosc Adv Surg Tech A* 2018;28:1334–45, <http://dx.doi.org/10.1089/lap.2018.0115>.
- [3] Di B, Li Y, Wei K, et al. Laparoscopic versus open surgery for colon cancer: a meta-analysis of 5-year follow-up outcomes. *Surg Oncol* 2013;22:e39–43, <http://dx.doi.org/10.1016/j.suronc.2013.03.002>.
- [4] Sheetz KH, Claflin J, Dimick JB. Trends in the adoption of robotic surgery for common surgical procedures. *JAMA Netw Open* 2020;3:e1918911, <http://dx.doi.org/10.1001/jamanetworkopen.2019.18911>.
- [5] Germain, A., P. Rouanet, A. Valverde. *Chirurgie Robotique Digestive*. Editions John Libbey Eurotext ed. Monographie de l'Association Française de Chirurgie 2021, Paris: Arnette.
- [6] Parisi A, Scrucca L, Desiderio J, et al. Robotic right hemicolectomy: analysis of 108 consecutive procedures and multidimensional assessment of the learning curve. *Surg Oncol* 2017;26:28–36, <http://dx.doi.org/10.1016/j.suronc.2016.12.005>.
- [7] Park JS, Choi GS, Park SY, Kim HJ, Ryuk JP. Randomized clinical trial of robot-assisted versus standard laparoscopic right colectomy. *Br J Surg* 2012;99:1219–26, <http://dx.doi.org/10.1002/bjs.8841>.
- [8] Park JS, Kang H, Park SY, et al. Long-term oncologic after robotic versus laparoscopic right colectomy: a prospective randomized study. *Surg Endosc* 2019;33:2975–81, <http://dx.doi.org/10.1007/s00464-018-6563-8>.
- [9] Voron T, Romain B, Bergeat D, et al. Prise en charge chirurgicale de l'adénocarcinome gastrique. Recommandations formalisées d'experts sous l'égide de l'Association française de chirurgie (AFC). *J Chir Visc* 2020;157:121–31, <http://dx.doi.org/10.1016/j.jchirv.2020.02.001>.
- [10] Miller SA, Forrest JL. Enhancing your practice through evidence-based decision making: PICO, learning how to ask good questions. *J Evid Based Dent Pract* 2001;1:136–41, [http://dx.doi.org/10.1016/S1532-3382\(01\)70024-3](http://dx.doi.org/10.1016/S1532-3382(01)70024-3).
- [11] Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *Bmj* 2008;336:924–6, <http://dx.doi.org/10.1136/bmj.39489.470347.AD>.
- [12] de'Angelis N, Lizzi V, Azoulay D, Brunetti F. Robotic versus laparoscopic right colectomy for colon cancer: analysis of the initial simultaneous learning curve of a surgical fellow. *J Laparoendosc Adv Surg Tech A* 2016;26:882–92, <http://dx.doi.org/10.1089/lap.2016.0321>.
- [13] Deutsch GB, Sathyanarayana SA, Gunabushanam V, et al. Robotic vs. laparoscopic colorectal surgery: an institutional experience. *Surg Endosc* 2012;26:956–63, <http://dx.doi.org/10.1007/s00464-011-1977-6>.
- [14] Lujan HJ, Maciel VH, Romero R, Plasencia G. Laparoscopic versus robotic right colectomy: a single surgeon's experience. *J Robot Surg* 2013;7:95–102, <http://dx.doi.org/10.1007/s11701-011-0320-5>.
- [15] Genova P, Pantuso G, Cipolla C, et al. Laparoscopic versus robotic right colectomy with extra-corporeal or intra-corporeal anastomosis: a systematic review and meta-analysis. *Langenbecks Arch Surg* 2021;406(5):1317–39, [http://dx.doi.org/10.1007/s01007/s00423-020-01985-x](http://dx.doi.org/10.1007/s01007/s00423-020-01985-x0423-020-01985-x). Epub 2020 Sep 9. PMID: 32902707.
- [16] Gerbaud F, Valverde A, Danoussou D, Goasguen N, Oberlin O, Lupinacci RM. Experience with transitioning from laparoscopic to robotic right colectomy. *JLS* 2019;23(4), <http://dx.doi.org/10.4293/jls.2019.00044>, e2019.00044.
- [17] Kelley SR, Duchalais E, Larson DW. Short-Term Outcomes with Robotic Right Colectomy. *Am Surg* 2018;84:1768–73.
- [18] Solaini L, Cavaliere D, Pecchini F, et al. Robotic versus laparoscopic right colectomy with intracorporeal anastomosis: a multicenter comparative analysis on short-term outcomes. *Surg Endosc* 2019;33:1898–902, <http://dx.doi.org/10.1007/s00464-018-6469-5>.
- [19] Trinh BB, Jackson NR, Hauch AT, Hu T, Kandil E. Robotic versus laparoscopic colorectal surgery. *JLS* 2014;18(4), <http://dx.doi.org/10.4293/jls.2014.00187>, e2014.00187.
- [20] Rausa E, Kelly ME, Asti E, Aiolfi A, Bonitta G, Bonavina L. Right hemicolectomy: a network meta-analysis comparing open, laparoscopic-assisted, total laparoscopic, and robotic approach. *Surg Endosc* 2019;33:1020–32, <http://dx.doi.org/10.1007/s00464-018-6592-3>.
- [21] Ma S, Chen Y, Chen Y, et al. Short-term outcomes of robotic-assisted right colectomy compared with laparoscopic surgery: a systematic review and meta-analysis. *Asian J Surg* 2019;42:589–98, <http://dx.doi.org/10.1016/j.asjsur.2018.11.002>.
- [22] Petrucciani N, Sirimarco D, Nigri GR, et al. Robotic right colectomy: a worthwhile procedure? Results of a meta-analysis of trials comparing robotic versus laparoscopic right colectomy. *J Minim Access Surg* 2015;11:22–8, <http://dx.doi.org/10.4103/0972-9941.147678>.

- [23] Rondelli F, Balzarotti R, Villa F, et al. Is robot-assisted laparoscopic right colectomy more effective than the conventional laparoscopic procedure? A meta-analysis of short-term outcomes. *Int J Surg* 2015;18:75–82, <http://dx.doi.org/10.1016/j.ijso.2015.04.044>.
- [24] Solaini L, Bazzocchi F, Cavaliere D, Avanzolini A, Cucchetti A, Ercolani G. Robotic versus laparoscopic right colectomy: an updated systematic review and meta-analysis. *Surg Endosc* 2018;32:1104–10, <http://dx.doi.org/10.1007/s00464-017-5980-4>.
- [25] Blumberg D. Robotic colectomy with intracorporeal anastomosis is feasible with no operative conversions during the learning curve for an experienced laparoscopic surgeon developing a robotics program. *J Robot Surg* 2019;13:545–55.
- [26] Megevand J, Amboldi M, Lillo E, et al. Right colectomy: consecutive 100 patients treated with laparoscopic and robotic technique for malignancy. Cumulative experience in a single centre. *Updates Surg* 2019;71:151–6.
- [27] Merola G, Sciuto A, Pirozzi F, et al. Is robotic right colectomy economically sustainable? A multicentre retrospective comparative study and cost analysis. *Surg Endosc* 2020;34(9):4041–7, <http://dx.doi.org/10.1007/s00464-019-07193-z>. Epub 2019 Oct 15.
- [28] Milone M, Elmore U, Allaix M, et al. Fashioning enterotomy closure after totally laparoscopic ileocolic anastomosis for right colon cancer: a multicenter experience. *Surg Endosc* 2020;34:557–63.
- [29] Solaini L, Cavaliere D, Pecchini F, et al. Robotic versus laparoscopic right colectomy with intracorporeal anastomosis: a multicenter comparative analysis on short-term outcomes. *Surg Endosc* 2019;33:1898–902.
- [30] Spinoglio G, Bianchi PP, Marano A, et al. Robotic versus laparoscopic right colectomy with complete mesocolic excision for the treatment of colon cancer: perioperative outcomes and 5-year survival in a consecutive series of 202 patients. *Ann Surg Oncol* 2018;25:3580–6.
- [31] Trastulli S, Coratti A, Guarino S, et al. Robotic right colectomy with intracorporeal anastomosis compared with laparoscopic right colectomy with extracorporeal and intracorporeal anastomosis: a retrospective multicentre study. *Surg Endosc* 2015;29:1512–21.
- [32] Hohenberger W, Weber K, Matzel K, Papadopoulos T, Merkel S. Standardized surgery for colonic cancer: complete mesocolic excision and central ligation—technical notes and outcome. *Colorectal Dis* 2009;11:354–64, <http://dx.doi.org/10.1111/j.1463-1318.2008.01735.x> [discussion 364–355].
- [33] West NP, Kobayashi H, Takahashi K, et al. Understanding optimal colonic cancer surgery: comparison of Japanese D3 resection and European complete mesocolic excision with central vascular ligation. *J Clin Oncol* 2012;30:1763–9, <http://dx.doi.org/10.1200/jco.2011.38.3992>.
- [34] Balciscueta Z, Balciscueta I, Uribe N, et al. D3-lymphadenectomy enhances oncological clearance in patients with right colon cancer. Results of a meta-analysis. *Eur J Surg Oncol* 2021;47(7):1541–51, <http://dx.doi.org/10.1016/j.ejso.2021.02.020>. Epub 2021 Feb 26.
- [35] Hohenberger W, Weber K, Matzel K, Papadopoulos T, Merkel S. Standardized surgery for colonic cancer: complete mesocolic excision and central ligation—technical notes and outcome. *Colorectal Dis* 2009;11:354–64.
- [36] Alhassan N, Yang M, Wong-Chong N, et al. Comparison between conventional colectomy and complete mesocolic excision for colon cancer: a systematic review and pooled analysis: a review of CME versus conventional colectomies. *Surg Endosc* 2019;33:8–18, <http://dx.doi.org/10.1007/s00464-018-6419-2>.
- [37] Ceccarelli G, Costa G, Ferraro V, De Rosa M, Rondelli F, Bugiantella W. Robotic or three-dimensional (3D) laparoscopy for right colectomy with complete mesocolic excision (CME) and intracorporeal anastomosis? A propensity score-matching study comparison. *Surg Endosc* 2020;35(5):2039–48, <http://dx.doi.org/10.1007/s00464-020-07600-w>. Epub 2020 May 5.
- [38] Yozgatli TK, Aytac E, Ozben V, et al. Robotic complete mesocolic excision versus conventional laparoscopic hemicolectomy for right-sided colon cancer. *J Laparoendosc Adv Surg Tech A* 2019;29:671–6.
- [39] Petruccianni N, Sirimarco D, Nigri GR, et al. Robotic right colectomy: a worthwhile procedure? Results of a meta-analysis of trials comparing robotic versus laparoscopic right colectomy. *J Minim Access Surg* 2015;11(1):22–8, <http://dx.doi.org/10.4103/10.4103/0972-9941.1476780972-9941.147678>.
- [40] Rondelli F, Balzarotti R, Villa F, et al. Is robot-assisted laparoscopic right colectomy more effective than the conventional laparoscopic procedure? A meta-analysis of short-term outcomes. *Int J Surg* 2015;18:75–82.
- [41] Solaini L, Bazzocchi F, Cavaliere D, Avanzolini A, Cucchetti A, Ercolani G. Robotic versus laparoscopic right colectomy: an updated systematic review and meta-analysis. *Surg Endosc* 2018;32:1104–10.
- [42] Haskins IN, Ju T, Skancke M, et al. Right colon resection for colon cancer: does surgical approach matter? *J Laparoendosc Adv Surg Tech A* 2018;28:1202–6.
- [43] Kang J, Park YA, Baik SH, Sohn S-K, Lee KY. A comparison of open, laparoscopic, and robotic surgery in the treatment of right-sided colon cancer. *Surg Laparosc Endosc Percutan Tech* 2016;26:497–502.
- [44] Widmar M, Keskin M, Strombom P, et al. Lymph node yield in right colectomy for cancer: a comparison of open, laparoscopic and robotic approaches. *Colorectal Dis* 2017;19:888–94.
- [45] Dolejs SC, Waters JA, Ceppa EP, Zarzaur BL. Laparoscopic versus robotic colectomy: a national surgical quality improvement project analysis. *Surg Endosc* 2017;31:2387–96, <http://dx.doi.org/10.1007/s00464-016-5239-5>.
- [46] Epidémiologie du cancer colorectal en France métropolitaine – Incidence. 2021 [28/02/2021]; Available from: <http://lesdonnees.e-cancer.fr/>.
- [47] Ceccarelli G, Andolfi E, Biancafarina A, et al. Robot-assisted surgery in elderly and very elderly population: our experience in oncologic and general surgery with literature review. *Aging Clin Exp Res* 2017;29:55–63, <http://dx.doi.org/10.1007/s40520-016-0676-5>.
- [48] Guerrieri M, Campagnacci R, Sperti P, Belfiori G, Gesuita R, Ghiselli R. Totally robotic vs 3-D laparoscopic colectomy: a single centers preliminary experience. *World J Gastroenterol* 2015;21:13152.
- [49] Liu D, Li J, He P, et al. Short- and long-term outcomes of totally robotic versus robotic-assisted right hemicolectomy for colon cancer: a retrospective study. *Medicine (Baltimore)* 2019;98:e15028, <http://dx.doi.org/10.1097/md.00000000000015028>.
- [50] Merola G, Sciuto A, Pirozzi F, et al. Is robotic right colectomy economically sustainable? A multicentre retrospective comparative study and cost analysis. *Surg Endosc* 2020;34:4041–7, <http://dx.doi.org/10.1007/s00464-019-07193-z>.