RANDOMIZED MULTICENTER STUDY PROTOCOL: APPLICATION OF 3D RECONSTRUCTION FOR PREOPERATIVE STRATEGY OF LOCALLY ADVANCED COLON CANCER

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INTRODUCTION

Colon cancer surgery is based on the central ligation of the tumor nutrient vessels, an intestinal margin free of tumor infiltration of 10 cm proximal and distal as well as dissection through embryological plane between the mesocolon and the retroperitoneum (1).

In locally advanced colon cancer (LACC) (T3-T4a-T4b according to TNM classification), the concept of circumferential margins free of infiltration or R0 surgery is essential. If tumor infiltration of neighboring structures is suspected, partial or total *en bloc* resection of the structure should be performed (2–5).

This type of surgery represents a challenge for colorectal surgeons since the risk of complications (25%) and postoperative mortality (5%) increases (4,6). As well as the risk of resections with affected surgical margins or R1 resection (11%) and as a consequence the rate of tumor recurrence and decreased survival at 5 years (6).

Due to its technical difficulty and the risks mentioned, the percentage of laparoscopic surgeries for this type of tumour is around 20% and the conversion rate is high (10%), which also increases the risk of postoperative complications (5,7,8).

The resection of this type of tumors is based on a preoperative surgical strategy based on extension computed tomography (CT scan). However, diagnosing infiltration of neighboring structures in colon cancer is also challenging for radiologists. In fact, its diagnostic accuracy is close to 40% (9,10).

For this reason, it is currently questionable whether it is correct to perform a *tailor-made* surgery in the LACC from the CT scan. In fact, in many cases the decision whether to resect or not a neighboring structures is decided according to the intraoperative findings, increasing the risk of positive margins and/or tumor perforation.

Currently, in addition to the direct resection of this type of tumor, there are two other therapeutic strategies with medical evidence. Adjuvant chemotherapy has been shown to increase the chance of R0 in T4b tumors and intraoperative chemotherapy that may decrease the occurrence of carcinomatosis in T4 tumors. However, both studies conclude that the application of these two strategies encounters the problem of over-staging by CT, with a percentage of 20-30% of T3 tumors preoperatively classified as T4 (11).

The research group of the current project leads a line of work of applying mathematical algorithms of 3D reconstruction to imaging techniques to improve surgical results in rectal and colon cancer. The result of this line of research are several publications in prestigious international journals (12–19). Specifically in colon cancer, the research guidelines considered to propose this randomized multicentre project. In which perioperative and oncological outcomes will be compared between two groups. In the control group (Group A) the surgical strategy will be established in a traditional way with the CT and the study group (Group B) will develop the strategy based on 3D-IPR.

In 2023, the pilot study entitled Application of 3D reconstruction and artificial intelligence for complete excision of mesocolon and D3 lymphadenectomy was published (20) Subsequently, in 2024, the single-centre prospective study funded by the Asociación Española de Coloproctología (AECP) was carried out, showing promising results from the application of this technology in the surgical strategy for locally advanced colon cancer. From this last work, the protocol entitled: Prospective observational non-randomized trial protocol for surgical planner 3D image processing & reconstruction for locally advanced colon cancer was published (13) These results have been presented at the following scientific meetings and the results have already been published in the European Journal of Surgical Oncology (21).

The aim of this study is to assess the usefulness of a mathematical model of three-dimensional image process and reconstuction (3D-IPR) as a surgical planner in locally advanced colon cancer. In addition to comparing the diagnostic accuracy of this planner with that of the CT regarding the infiltration of neighbouring structures.

JUSTIFICATION AND OBJECTIVES

HYPOTHESIS: A 3D reconstruction model based on mathematical algorithms from CT scan could decrease perioperative morbidity and mortality, increase the percentage of minimally invasive approaches, and increase the probability of R0 resections in LACC. In addition, it may increase the diagnostic accuracy of suspected tumor infiltration of neighboring structures in advanced colon tumors.

OBJECTIVES:

Primary Objective:

To evaluate whether mathematical models of three-dimensional reconstruction (3D-IPR) enable R0 resection in patients with threatened surgical margins (TSM) in locally advanced colon cancer (LACC).

Secondary Objectives:

1. To determine the effect of 3D-IPR on perioperative complications.
2. To evaluate its impact on the use of minimally invasive surgical approaches.
3. To assess its influence on conversion rates from minimally invasive to open surgery.
4. To compare the diagnostic accuracy of 3D-IPR with standard CT radiological reports for assessing infiltration of adjacent structures.
5. To analyze survival outcomes, including overall survival (OS) and disease-free survival (DFS).
6. To evaluate locoregional and distant recurrence rates over a 5-year follow-up.

OUTCOMES

Primary Outcome:

- **R0 resection rate:** Defined as microscopically margin-negative resection in patients with TSM undergoing surgery planned using 3D-IPR.

Secondary Outcomes:

- **Perioperative complications:** Incidence and severity within 30 days post-surgery, classified by the Clavien-Dindo grading system.
- **Conversion to open surgery:** Rate of patients requiring intraoperative conversion from minimally invasive to open surgery following 3D-IPR planning.
- **Minimally invasive surgery utilization:** Proportion of patients undergoing laparoscopic or robotic surgery.
- **Diagnostic performance:** Sensitivity, specificity, positive and negative predictive values, and overall accuracy of 3D-IPR versus CT; agreement measured by Cohen's kappa coefficient.
- **Survival outcomes:** OS (time from surgery to death from any cause) and DFS (time from surgery to recurrence or death, whichever occurs first).
- **Recurrence:** Proportion of patients with locoregional or distant recurrence over 5 years.

Justification:

If greater diagnostic accuracy is observed for this mathematical method of 3D reconstruction with respect to infiltration of neighboring structures in locally advanced colon tumors:

- The radiologist would have an objective tool to delimit the tumor extension.
- The surgeon would have an objective tool to plan the type of surgical intervention with the least probability of modifying intraoperatively. In addition, this 3D tool facilitates the preoperative visualization of the tumor location.
- The preoperative simulation of different surgical routes to resect the tumour would allow the ideal one to be selected to do so in a minimally invasive approach. This fact has shown advantages over traditional laparotomy.
- Mutilating surgeries due to a false positive diagnosis of infiltration of neighbouring structures could be avoided.
- This type of intervention could require the collaboration of other specialties such as gynaecology, urology, vascular surgery, traumatology and plastic surgery. Correct scheduling of the type of extended resection to be performed is essential. To this end, this tool would provide the necessary data for this purpose.
- The discussion of this type of pathology in a Multidisciplinary Committee (MDC) within reference Colorectal Units is frequent and knowing the exact degree of infiltration of anatomical structures facilitates decision-making. At present, there are different therapeutic lines for locally advanced colon tumours. Among them we find direct surgery and subsequent adjuvant chemotherapy. There is also evidence of neoadjuvant chemotherapy and subsequent resection, and finally recent studies propose surgery with intraoperative hypertemic peritoneal chemotherapy (HIPEC). For this reason, correct staging is essential to avoid overtreatment.

- An R0 surgery decreases the risk of oncological recurrence. This fact decreases the number of patients who require chemotherapy treatment for this reason, long-term follow-ups, number of face-to-face consultations and complementary tests.

In this way, 3D reconstruction is a tool that could provide digital solutions for health and care, promoting the development and use of these innovative techniques to improve the quality of life of patients. For this reason, it is necessary to highlight the need to promote the development of these technologies taking into account interoperability, security, confidentiality and standardization systems, for the improvement of health care.

Surgery for locally advanced colon tumors has a rate of postoperative complications that can be high, as well as a positive surgical margin risk. This tool could improve these results considerably.

An important advantage is the fact that the patient is not summited to a new diagnostic test to obtain this reconstruction, since it is performed using CT scan images done during staging oncologic protocols.

Material and methods

A randomized prospective multicenter study will be carried out in 5 Colorectal Surgery Units of the following 3rd level of care hospitals, over a period of two years.

1. Son Espases University Hospital, Balearic Island, Spain.
2. Hospital Álvaro Cunqueiro, Galicia, Spain.
3. Reina Sofía General University Hospital, Murcia, Spain.
4. Josep Trueta University Hospital, Girona, Spain.
5. Ramón y Cajal Hospital, Madrid, Spain.

Inclusion criteria:

1. Patients of both sexes, aged ≥18 years.
2. Adenocarcinoma of the right, left, sigmoid and recto-sigmoid junction that have cT3 or cT4a/b according to the eighth TNM edition of the American Joint Committee on Cancer (AJCC). Pre-treatment diagnosis by imaging (CT) test.
3. Lymph node extension: cN0, the presence of cN1/2 according to AJCC TNM 8th edition is allowed as long as they can be resected. Pretreatment diagnosis by imaging (CT) test.
4. Patients who access and sign informed consent for the surgical intervention.

Exclusion criteria:

1. Suspected carcinomatosis on preoperative CT or intraoperative finding
2. Suspected distant metastasis on preoperative CT or intraoperative finding
3. Patients with tumors with infiltration considered to be unresectable (pre-surgical or intraoperatively), since the anatomical-pathological analysis will not be available.

Mathematical method of 3D reconstruction (3D-IPR)

- 3D mathematical reconstruction from the extension CT, which is performed on all patients with colon neoplasms, to assess the location of the primary colon tumor and possible infiltration of neighboring/retroperitoneal structures.
- Assessment of the same parameters presented for the CT scan of the abdomen.
- The mathematical reconstruction will be based on two concepts:

  1. Preprocessing of extension CT using "Polarization Field Correction" algorithms and radiomics-based anisotropic diffusion filters of the image.

  2. Segmentation of medical image in the different sequences provided using sequence of algorithms based on active contour methods, modified dynamic search and based on atlases. Finally, the 3D surface will be reconstructed using modified "marching cube" algorithms.

Utilities of the 3D Reconstruction surgical planner:

1. Exact tumor size
2. Exact tumor location
3. Mathematical extension of 10 cm proximal and distal resection area.
4. Arterial and venous vascularization of the resection area
5. Location of possible lymphadenopathies
6. Minimum distance of the tumor from the different anatomical structures
7. Location of possible areas of tumour infiltration
8. Tumor infiltration volume in cm^3
9. Simulation of surgical resection with a margin of 5 and 10 mm.

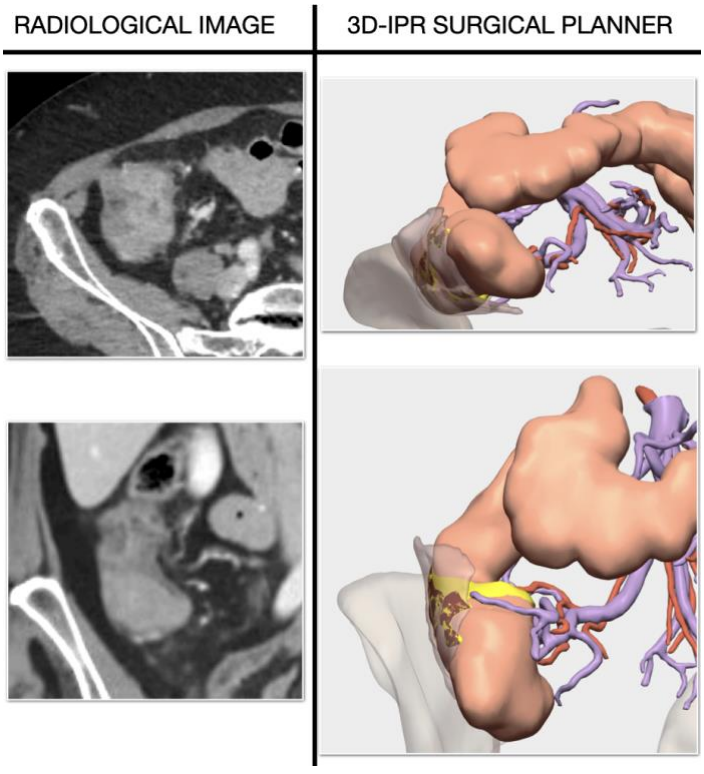

Figure 1: Locally advanced right colon cancer. CT scan on the left with no parietocolic or retroperitoneal infiltration. 3D-IPR on the right with infiltration of the parietocolic ligament and

retroperitoneum. The detailed vascularization of the colon is also observed, as well as the mathematical location of the tumor.

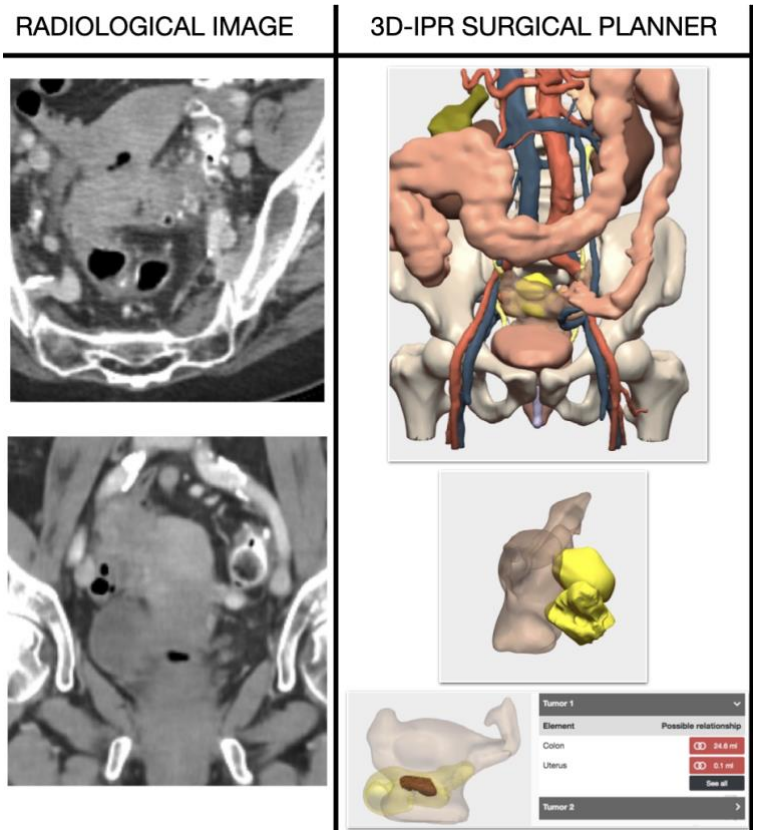

Figure 2: Locally advanced sigmoid colon cancer. CT scan on the left with unclear definition of the plane of separation between tumor, bladder and uterus. 3D-IPR on the right showing uterine infiltration, no bladder intration as well as exact tumoral size and location.

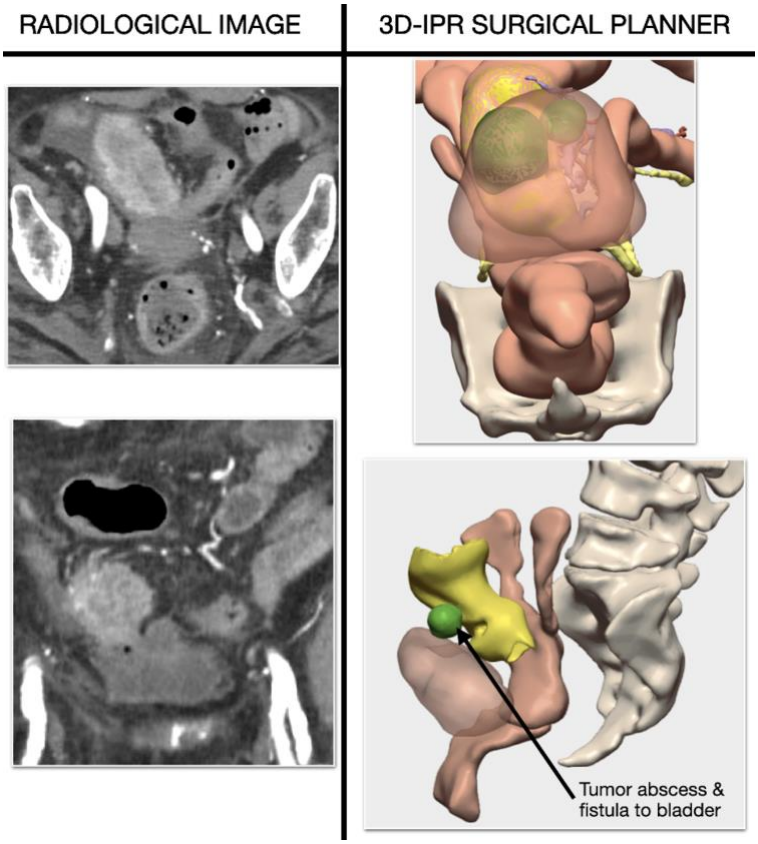

Figura 3: Locally advanced sigmoid colon cancer with an abscess and fistula between colon and bladder. To the left, CT scan does not show plane of separation between tumor and bladder. 3D-IPR shows abscess and fistula bewtween sigmoid and bladder, no tumor infiltration.

Anatomopathological study:

1. The surgical specimens are processed and fixed in 10% formaldehyde and the quality of the complete excision of the mesocolon and tumor staging will be evaluated according to current anatomopathological clinical guidelines.
2. 4mm thick cross-sections will be made on the piece (each of the sections are digitally photographed) from the proximal portion, including the tumor area, to visualize the relationship of the cancer with the circumferential margin of resection. Thus, the location of the tumor is evaluated in relation to the retroperitoneal margin: above, at or below it; and with the rest of the adjacent resected structures.
3. For the microscopic study, sections are included by quadrants in blocks, choosing the sections with the greatest infiltrative component in the intestinal wall, closest to the circumferential margin painted with Indian or orange ink.
4. Samples are included and stained with hematoxylin-eosin following the standard methodology for histological evaluation.
5. The parameters analyzed are those of the protocol already established in the reference unit.

Variables

The following will be considered a tumor infiltration zone after the anatomopathological study: Presence of infiltrating tumor cells in the neighboring anatomical structure. Need for a photograph of the anatomopathological study sheet.

Assessment of diagnostic accuracy of 3D-IPR with respect to tumor infiltration in the group of randomized patients in whom 3D-IPR was performed:
Microscopic analysis of each of the structures marked as infiltrated by 3D-IPR. Need for a picture photograph of the pathological study.

CT Scan report comparison respect to:
Tumor infiltration of neighboring structures: Comparison by microscopic study of each of the anatomical structures.

Comparison with the CT scan report regarding:
Suspected or not of being infiltrated areas according to the CT and 3D-IPR.

Sample size:
The sample size will be determined by considering all cases that meet the established inclusion and exclusion criteria, over a period of two years in the participating centers. Based on previously published data with R0 rates of 89% in cases of LACC (10,22,23)
The sample size of this study was calculated with the aim of evaluating the efficacy of mathematical models of three-dimensional reconstruction (3D-IPR) in improving the rate of R0 resections in patients with threatened surgical margin (TSM) in locally advanced colon cancer.
The following parameters were assumed:

1. R0 resection rate in the control group (Group A): Based on previous studies, a rate of 89% is considered when using traditional surgical strategies.
2. Expected R0 resection rate in the intervention group (Group B): An improvement is expected, reaching at least 95% R0 rate by using the 3D-IPR
3. Level of significance (α): It was established at 0.05, which corresponds to 95% confidence.
4. Statistical power (1−β1): It was set at 90%, to ensure a high probability of detecting real differences between the groups.
5. Allocation ratio: An equal allocation (1:1) was used between the control group and the intervention group.

$$n = \frac{(Z_\alpha \cdot \sqrt{2 \cdot p_{\text{pooled}} \cdot (1 - p_{\text{pooled}})} + Z_\beta \cdot \sqrt{p_1 \cdot (1 - p_1) + p_2 \cdot (1 - p_2)})^2}{(p_2 - p_1)^2}$$

When the formula is applied, it results in a sample size of 67 patients in each group.

On the other hand, it is expected that each center will intervene between 12 and 14 patients annually who meet the characteristics defined in the methodology. This estimates that the five centers will perform approximately 84 interventions per year, resulting in a projected total of 168 cases at the end of the two years of study, which is compatible to reach the desired sample size to statistically validate the results.

Randomization method:

Participants will be assigned to two groups using a 1:1 randomization process. The control group (Group A) will follow the conventional procedure to establish the surgical strategy, using the images obtained by computed tomography (CT) as a basis. On the other hand, the study group (Group B) will implement surgical planning using the 3D-IPR surgical planning.

To ensure an unbiased and standardized assignment, we will employ a website specifically designed for the study and this type of randomization (https://www.sealedenvelope.com/). This page will allow the users to enter an anonymized code for each patient, guaranteeing data protection and data confidentiality. Once the code has been entered, the system will determine which group the patient will be assigned to, following the previously configured 1:1 randomization scheme. This assignment will allow the number of patients to be balanced equally between both groups, minimizing biases and optimizing the statistical validity of the results.

Study Variables:

	VARIABLE	VALORES
Demographic Variables	HOSPITAL	Text
	ID – 3D	Numeric/Text
	Sexo	0: Female 1: Male
	Date of birth	Numeric
	Age	Cuantitative discreta (años)
	ASA	0: ASA I 1: ASA II 2: ASA III 3: ASA IV 4: ASA V 5: ASA VI
	BMI	Numeric
	Aleatorization	0: Group A (Control Group) 1: Group B (3D Group)
Pre-Operative Variables	Diagnosis	0: Right colon neoplasm 1: Hepatic flexure neoplasm 2: Transverse colon neoplasm 3: Splenic flexure neoplasm 4: Descending colon neoplasm 5: Sigmoid colon neoplasm
	Neoadjuvant chemotherapy	0: No

		1: Yes
	Neoadjuvant radiotherapy	0: No 1: Yes
	Neoadjuvant immunotherapy	0: No 1: Yes
	Resectable disease defined in multidisciplinary committee?	0: No 1: Yes
CT scan variables	Neighbouring structures infiltration (Confirmed or suspicion) in CT scan?	0: No 1: Yes
	Infiltrated structures in CT scan	0: Retroperitoneal fascia 1: Parietal fascia 2: Uterus 3: Bladder 4: Duodenum 5: Kidney 6: Urether 7: Others
	Other infiltrated structures in CT scan	Text
	Distant Metastasis	0: No 1: Yes
	cT stage	0: cT0 1: cT1 2: cT2 3: cT3 4: cT4a 5: cT4b 6: Not reported
	cN Stage	0: N0 1: N (+) 2: Not reported
3D Reconstruction variables	Neighbouring structures infiltration in 3D-IPR?	0: No 1: Yes
	Infiltrated structures in 3D-IPR	0: Retroperitoneal fascia 1: Parietal fascia 2: Uterus 3: Bladder 4: Duodenum 5: Kidney 6: Urether 7: Others
	Other infiltrated structures in 3D-IPR	Text
	Total Infiltration volumen in 3D-IPR	Numeric (mm3)
Intraoperative variables	Surgery date	Numeric
	Surgical Approach	0: Laparotomy 1: Minimally invasive
	Conversion to open surgery	0: No 1: Yes
	Type of surgical procedure	0: Right colectomy 1: Extended right colectomy 2: Splenic flexure segmentary resection 3: Left colectomy 4: Sigmoidectomy 5: Extended left colectomy 6: Subtotal colectomy
	Intraoperative carcinomatosis	0: No 1: Yes

	Resectable tumor?	0: No 1: Yes
	Surgical time	Numeric (Minutes)
	Extended resection	0: No 1: Yes
	Partial or total en bloc resection of neighbouring structures	0: Partial 1: Total
	Neighbouring structure resected	0: Retroperitoneal fascia 1: Parietal fascia 2: Uterus 3: Bladder 4: Duodenum 5: Kidney 6: Urether 7: Others
	Other neighbouring structures resected	Text
	Discharge date	Numeric (date)
	Postoperative stay	Numeric (days)
Anatomopathology Variables	Histology	0: Adenocarcinoma 1: Other
	Differentiation	0: G1 Well differentiated 1: G2 Moderately differentiated 2: G3 Poorly differentiated
	pT stage	0: cT0 1: cT1 2: cT2 3: cT3 4: cT4a 5: cT4b
	pN Stage	0: N0 1: N (+)
	Total number of lymphnodes	Numeric
	Total of positive lymphnodes	Numeric
	Lymphnode ratio	Numeric = Positive lymphnodes/Total number of lymphnodes
	Vascular infiltration	0: No 1: Yes
	Lympathic infiltration	0: No 1: Yes
	Perineural infiltration	0: No 1: Yes
	Tumoral deposits	0: No 1: Yes
	Stage	1: Stage 1 2: Stage 2 3: Stage 3 4: Stage 4
	Infiltrated structures in pathology?	0: No 1: Yes
	Neighbouring structure infiltrated	0: Retroperitoneal fascia 1: Parietal fascia 2: Uterus 3: Bladder 4: Duodenum 5: Kidney 6: Urether 7: Others

	Other neighbouring structures infiltrated	Text
	Type of resection?	0: R0 1: R1/R2
	Infiltration of proximal margin	0: No 1: Yes
	Infiltration of distal margin	0: No 1: Yes
	Infiltration of circumferential margin	0: No 1: Yes
Post-Operative Variables	Complications: Clavien-Dindo Classification	0: 0 1: 1 2: 2 3: 3 4: 4 5: 5
	Surgical Re-intervention	0: No 1: Yes
	Cause of surgical re-intervention	0: Anastomotic leak 1: Hemoperitoneum 3: Evisceration 4: Intestinal obstruction from adhesions 5: Other
	Other causes of surgical re-intervention	Text
	Adjuvant chemotherapy	0: No 1: Yes
Follow-up Variables	Date of last follow-up	Date
	Local recurrence	0: No 1: Yes
	Date of local recurrence	Date
	Distant recurrence	0: No 1: Yes
	Date of distant recurrence	0: No 1: Yes
	Recurrence as Peritoneal carcinomatosis	0: No 1: Yes
	Date of recurrence as peritoneal carcinomatosis	Date
	Death	0: No 1: Yes
	Death secondary to disease progression	0: No 1: Yes
	Death date	Date

Oncological variables analyzed at 3 and 5 years:

1. Locoregional recurrence: intraluminal growth of the tumor near the suture or inside the cavity near the previously operated location.
2. Distant recurrence: Distant metastasis outside the abdominal cavity.
3. Peritoneal carcinomatosis: Carcinomatosis will be considered when there are tumour implants in at least two different areas of the abdominal cavity with an anatomopathological diagnosis of the presence of tumour cellularity. This allows it to be differentiated from regional loco recurrence.
4. Disease-free survival: Time from surgery to the date recurrence is documented.

5. Overall survival: time from admission to death from any cause (includes 90-day postoperative mortality).
6. Mortality due to oncological progression.

All patients with recurrent disease should be confirmed, if possible, histologically or by radiological imaging or resurgical intervention.

Statistical method

The qualitative variables will be expressed by sample size and percentage. The categorical variables will be expressed by the median and the range.

In the nonparametric univariate analysis, continuous variables will be compared using the Kruskal-Wallis test, while categorical variables will be compared with the Fisher Exact test. A p< value 0.05 will be considered statistically significant.

Database Data Protection:

Database (DB) Data Storage and Access Policy Report.

A database will be created, for which each collaborator will have a unique username and password to be able to include the patients in the study. The main investigator will be the only one who will be able to have access to the aggregated patients of each center. Collaborators will only be able to add and modify their own patients, without access to patient information from the other hospitals. In this way, it is the main researcher who will be in charge of collecting information from all the centers in order to analyze the results.

The information will be stored on cloud servers owned by Oracle. The information is encrypted in the database so any direct access to it is useless, unless the private key is known. Data that could be used to locate the patient such as name, surname, ID, etc., is not requested. The only data that could be used is the Chart history number, which is cut, so that the user who reports data can locate the correspondence in his hospital, that is, he must have the real data written down in a place controlled only by him (such as the hospital's own management program) in order to locate that patient.

In the case of access to the application by someone who is not authorised, but who has obtained a username and password with access to read patients from their own and other hospitals, the available information does not serve to "de-anonymize" the data. Accesses to the application, writes, reads, etc. are recorded by the application so that any access without express authorization can be located.

On the other hand, the coordinator of the Simulation and 3D Printing Unit of the Son Espases University Hospital, and the coordinator of each research centre, will be in charge of anonymizing the data of the patients in the study. In this way, they can be provided to the company CELLA MEDICAL SOLUTIONS ®, anonymously and safely, to carry out the three-dimensional reconstructions necessary for the study.

Work plan

During the first 2 months, coordination will be carried out between all the centres involved, as well as the creation of the digital database.

During the following two years, the surgical centers will perform:

- Identification of patients who are candidates for the study according to material and methods.
- Referral of the pre-operative CT scan to Innovación y Tecnología Médicas Cella (proprietary software) for the elaboration of the 3D-reconstruction and assessment of tumor infiltration.
- Surgical intervention.
- Detailed microscopic study of the surgical specimen and definitive anatomopathological report.
- Incorporation of data into the prospective database.
- Forwarding of all microscopic images to the main investigator for storage.

During the following 6 months, the result analysis will be carried out, evaluation of strategies and results communications.

The dissemination of the results will be carried out in the main congresses of General Surgery and the Digestive System, such as the National Congress of Surgery of the Spanish Association of Surgeons (AEC), the National Congress of the Association of Coloproctology (AECP), the International Congress of the European Society of Coloproctology (ESCP), as well as the International Conference on Coloproctology that is held annually in Baiona. Galicia.

On the other hand, to extend the dissemination of the results, the articles that may come from this research will be sent for publication to international journals if possible, in Q1 according to the Journal Citation Reports (JCR).

This study will comprise the following stages:

1. **Phase 1.** Knowledge of the different centers in the study protocol. Each of the centers must present perfect coordination with four different specialties: colorectal surgery, pathological anatomy, radiology, oncology.
    1. To establish this coordination, two digital workshops will be held in which a member of each of these specialties from each of the centers involved will participate.
2. **Phase 2**. Each of the centres will carry out the action protocol test for three cases. These cases will not be included in the assessment of results.
3. **Phase 3.** Choice of cases. For the choice of cases, the guidelines set out in the protocol will be followed. If there are any doubts, the main coordinator of the study will provide a contact telephone number and e-mail.
4. **Phase 4.** Surgical intervention of patients.
5. **Phase 5.** Analysis of the surgical specimen by pathological anatomy. For the pathological study of the cases, the guidelines set out in the protocol will be followed.
6. **Phase 6.** Incorporation of results into the database. Database created especially online for this study. A specific workshop will be held to explain how the database works. If there is any doubt, the main coordinator of the study will provide a contact telephone number and email of the creator of the database as a reference.
7. **Phase 7.** Analysis of results by the main coordinator of the study.
8. **Phase 8.** Analysis of survival outcomes at 3 years.

9. **Phase 9**. Analysis of 5-year survival outcomes.

Ethical considerations

The present study does not intend to change the current standards of quality surgery in colon cancer. The research seeks to give surgeons tools so that interventions can be performed with better oncological results that ultimately translate into greater survival. On the other hand, data such as names or medical history that could be used to identify patients will not be included.

Likewise, the therapeutic strategy to be used will be decided during the multidisciplinary colorectal oncology committee and ultimately based on the intraoperative findings. The radiologist will perform the report independently of the 3D reconstruction. The 3D reconstruction will be used by the surgeon to assess the surgical strategy.

DISCUSION

3D reconstruction could help colorectal surgeons plan the optimal surgical strategy in the LACC.

Its diagnostic difficulty, its surgical challenge and the different therapeutic options make this type of tumour a challenge in the multidisciplinary oncology committees.

According to some series with a high number of patients, the risk of major complications is 25% and mortality rate is 5% (3,5) In the study carried out in the single center series, no patient presented major complications or mortality at 30 days. In addition, minimally invasive surgery was performed in 70% of the cases compared to 25% observed in the literature (21).

The decision of this approach must be correct, since conversion to laparotomy increases the risk of complications and R1 surgeries. In the current literature, the conversion rate is 10% for these tumors, while in the present series it was 0%.

These excellent results in terms of morbidity and mortality have been achieved thanks to good preoperative planning. So far, this planning has been carried out based on the imaging test of oncological staging such as CT. However, some authors have already proposed the usefulness of 3D reconstruction models obtained from imaging tests as surgical tools to help plan the best approach method and the best surgical route.

There are different types of 3D reconstruction, depending on the type of segmentation: manual, semi-automatic and automatic.

Some authors already doubt whether surgeries should be planned based on CT for LACC due to its poor diagnostic accuracy compared to infiltration of neighboring structures (35-50%) and highlight the need to incorporate new technologies. As has been published in previous pilot studies of rectal cancer, mathematical image processing algorithms could improve these diagnostic parameters (2,4,9,24–32).

The decision of *en bloc* or partial resection of a structure neighboring the tumor due to suspected infiltration should be made before starting surgery, since if not, the risk of R1-R2 type resection increases. This fact will directly influence patient survival since disease-free survival at 5 years changes from 40% in patients classified as R1 to 75% in those classified as R0. The published percentage of R1 resections in LACC is 11%, while in the present unicenter series it was 0%. A high positive predictive value will help to make the decision to resect neighboring structures.

On the other hand, overstaging causes unnecessary resections that can decrease the patient's quality of life unnecessarily.

LACC can present infiltration of multiple structures. Special mention must be made of the retroperitoneal fascia. Ascending and descending colon tumors are a challenge for radiologists, surgeons, and pathologists alike. If this structure is infiltrated, it should be considered as cT4b in the staging CT, however as pT3 in the pathological study if it does not perforate to and invade retroperitoneal structures. On the other hand, the surgeon must modify the proposed surgery in the complete mesocolic excision (CME) technique and use what is beginning to be defined as Extended-Mesocolic excision (EME) That is, incorporating the retroperitoneal fascia into the surgical specimen to achieve an infiltration-free retroperitoneal margin (33,34).

Finally, the different therapeutic strategies proposed in the literature for LACC are based on correct preoperative staging. On one hand, as we have mentioned, the direct approach through surgery and obtaining R0 and subsequent chemotherapy is for the moment the treatment of choice. However, some authors have shown that in T4 tumors neoadjuvant chemotherapy could increase the possibility of obtaining R0 surgery and others defend the usefulness of intraoperative chemotherapy to reduce the risk of developing carcinomatosis. These last two therapeutic options have the same limitation, which is the 30% of patients classified as T4 in the CT scan who will be T3 in the pathology report and will therefore be overtreated.

CONCLUSIONS

If greater diagnostic accuracy is observed for this 3D-IPR with respect to infiltration of neighboring structures in locally advanced colon tumors:

- The radiologist would have an objective tool to delimit the tumor extension.
- The surgeon would have an objective tool to program the type of surgical intervention with the least probability of modifying it during the operative time. In addition, this 3D tool facilitates the preoperative visualization of the tumor location.
- The preoperative simulation of different surgical routes to resect the tumour would allow the ideal one to be selected to do so in a minimally invasive way.
- Mutilating surgeries could be avoided due to a false positive diagnosis of infiltration of neighboring structures.
- An R0 surgery decreases the risk of oncological recurrence. This fact decreases the number of patients who require chemotherapy treatment for this reason, long-term follow-ups, number of face-to-face consultations and complementary tests.

In this way, 3D reconstruction is a tool that could provide digital solutions for health and care, promoting the development and use of these innovative techniques to improve the quality of life of patients. For this reason, it is necessary to highlight the need to promote the development of these technologies taking into account interoperability, security, confidentiality and standardization systems, for the improvement of health care.

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