

The Use of a Vascular Roadmap at Surgery Evens out Surgeons' Expectations on Operating Time, Blood Loss, Lymph Nodes Harvest and Operative Difficulty when Performing Right Colectomy with Extended D3 Mesenterectomy

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Rezumat

Utilizarea preoperatorie a unei hărți vasculare uniformizează așteptările chirurgilor cu privire la durata operației, pierderea de sânge, numărul ganglionilor limfatici recoltați și dificultatea intervenției atunci când se efectuează colectomia dreaptă cu mezenterectomie D3 extinsă

Scop: Determinarea modului în care maparea traiectelor vasculare individuale influențează așteptările chirurgilor cu privire la dificultatea colectomiei drepte D3 pentru cancer și compararea acestor așteptări cu rezultatele publicate anterior.

Context: Literatura încă nu are date despre așteptările chirurgilor care utilizează preoperator harta 3D a sistemului vascular.

Metodă: Chirurgii au completat un sondaj despre așteptările lor cu privire la durata operației, cantitatea estimativă de sânge pierdut, numărul de ganglioni limfatici recoltați și dificultatea intervenției. Pacienții au fost clasificați în 4 grupe și 2 subgrupe în funcție de traseul arterei ileocolice și al venelor jejunale. Pentru analiza statistică a fost utilizat SPSS.

Rezultate: Doisprezece chirurghi incluși. 8/12 se așteptau ca anatomia de tip 2 să consume cel mai puțin timp, în timp ce 11/12 au indicat că grupa de anatomie 4 să necesite cel mai lung timp operator. 5/12 chirurghi se așteptau la pierderi de sânge scăzute la pacienții cu anatomie din grupul 2, în timp ce 10/12 se așteptau la pierderi mai mari de sânge la pacienții cu anatomie din grupul 4. 3/12 au anticipat că grupul 2 va genera cel mai mare randament de ganglioni limfatici, în timp ce 2/12 chirurghi se așteptau la cel mai scăzut număr de ganglioni recoltați în grupul de anatomie 4. 8/12 au perceput grupul 2

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ca fiind cel mai accesibil, în timp ce 10/12 au indicat grupul 4 ca cel mai dificil. În comparație cu rezultatele publicate anterior, numai timpul operator al grupului 4b a îndeplinit așteptările chirurgilor.

Concluzie: Utilizarea preoperatorie a unei hărți vasculare uniformizează așteptările chirurgilor în ceea ce privește durata intervenției, pierderea de sânge, numărul de ganglioni limfatici recoltați și dificultatea operației. Compararea rezultatelor cu datele publicate anterior arată că durata operației într-un grup de anatomie este singurul factor în care aceste așteptări au fost îndeplinite.

Cuvinte cheie: colectomie dreaptă, cancer de colon, chirurgie ghidată imagistic, mezenterectomie D3 extinsă, anatomie vasculară 3D, hartă vasculară

Abstract

Purpose: To determine how individual vascular road-mapping impacts the surgeons' expectations in difficulty in D3 right colectomy for cancer, and compare these expectations to the results previously published.

Aim/summary background data: Literature still lacks data on surgeons' expectations using preoperative 3D roadmap of the vascular system.

Method: Surgeons filled out a survey asking expectations about operation time, estimated blood loss, amount of lymph nodes harvested and difficulty. The patients were classified into 4 groups and 2 subgroups according to the crossing pattern of the ileocolic artery and the jejunal veins. SPSS was used for statistical analysis.

Results: Twelve surgeons were included. Eight of them expected type 2 anatomy to be least time consuming while 11/12 indicated anatomy group 4 to be the most. Five surgeons expected low blood loss in group 2 anatomy patients while 10/12 expected higher blood loss in group 4 anatomy patients. Three anticipated that group 2 would generate the highest lymph node yield and while 2/12 surgeons expected the lowest in anatomy group 4. Eight surgeons perceived group 2 as the least challenging while 10/12 experienced group 4 as the most difficult. Compared to previously published results only group 4b operating time met surgeons' expectations.

Conclusion: Using a vascular roadmap at surgery evens out surgeons expectations' in operation time, blood loss, lymph node harvested and difficulty. Comparing expectations to previously published data shows operating time in one anatomy group as the only factor where these expectations were met.

Key words: right colectomy, colon cancer, image guided surgery, extended D3 mesenterectomy, 3D vascular anatomy, surgical roadmapping

Introduction

Multiple factors are known to impact the difficulty of surgery. Known indicators of challenging surgery are longer operating times and higher blood loss (1,2). Literature states that a higher lymph node harvesting is associated with better survival (3), implying that level of dissection III (D3) can benefit the patient (4). Obesity (5), previous surgery (6)

and adhesions (7) are shown to cause longer operating time, while unpredictable anatomical variations of the vascular anatomy can lead to increased blood loss.

A previous article from our research group (8) has reported the impact of individual vascular road-mapping on blood loss, operating time and lymph node harvest in different anatomy groups of patients. In this study the surgeons had a 3-D roadmap of the central

mesenteric vascular anatomy available prior to surgery allowing for the preoperative planning in patients stratified to different anatomy groups. These groups had a certain expectation of difficulty at surgery, implying that some of the anatomy groups were expected to be more challenging than others.

The aim of this study is to determine if using a vascular roadmap before surgery evens out surgeons' expectations in operation time, blood loss, lymph node harvest and difficulty, and to compare these expectations to the results previously published.

Material and Methods

The subjects analyzed in this study are surgeons including patients into the "Safe D3 Right Hemicolectomy for cancer through Multidetector Computed Tomography (MDCT) Angiography" trial (regional Ethical Committee approval REK Sør-Øst no. 2010/3354) and registered at clinicaltrials.gov (NCT01351714). Participation was voluntary for surgeons, who were asked to complete a survey, and did not require ethical committee approval. The trial includes a mandatory 3D reconstruction of the vascular anatomy before surgery, a standardized definition of the D3 volume, a standardized procedure and surgical approach to the central (level of dissection III) lymph nodes, a previously published classification of the vascular anatomy (9) and separate histopathological analysis of the D3 volume. Even though a plethora of various elements can alter the procedure of a pathway, this work examines the surgeons' expectations of the extended mesenterectomy that is mainly based on the minute dissection of the superior mesenteric vessels within a small area of the central mesenteric fatty tissue. The 3D roadmap (4) is derived from the preoperative CT dataset through manual segmentation using several image processing software products (FDA approved Osirix MD v. 12.0.1 (Pixmeo, Bernex, Switzerland), Mimics Medical image processing software, ver. 22.0, and 3-matic Medical software, ver. 14.0, both Windows 7 ultimate edition×64 2017

(Materialise NV, Leuven, Belgium)), resulting in morphometrically analyzed and annotated 3D models exported as still images, video clips or printable STL files.

The classification of the vascular anatomy groups was as follows (8,9) (*Fig. 1*):

- Type 1: Ileocolic artery crosses anteriorly to the superior mesenteric vein, jejunal vein crosses anteriorly to the superior mesenteric artery;
- Type 2: Ileocolic artery crosses anteriorly to the superior mesenteric vein, jejunal vein crosses posteriorly to the superior mesenteric artery;
- Type 3: Ileocolic artery crosses posterior to the superior mesenteric vein, jejunal vein crosses posteriorly to the superior mesenteric artery;
- Type 4a: Ileocolic artery crosses posteriorly to the superior mesenteric vein, jejunal vein crosses anteriorly to the superior mesenteric artery concealing the ileocolic artery origin;
- Type 4b: Ileocolic artery crosses posteriorly to the superior mesenteric vein, jejunal vein crosses anteriorly so as not to conceal the ileocolic artery.

All surgeons in the trial were asked to contribute through filling out a survey on their expectations at surgery concerning the impact of the anatomy groups as previously described (1, 2, 3, 4a, 4b). The questionnaire was distributed through e-mail: 1) In which anatomy group do you expect longer operating times? 2) In which anatomy group do you expect higher blood loss? 3) In which anatomy group do you expect the highest lymph node harvest? 4) In which anatomy group do you anticipate the highest difficulty of surgery? The surgeons were asked to grade the anatomical groups with numbers 0-4, where 4 was the highest value and 0 was the lowest. Surgeons were also provided with the following option, if no difference between the groups was expected, to grade some or all groups with the same number as long as the sum of all points was 10.

The statistical analyses were carried out by means of Statistica 14.0, TIBCO Software Inc. (2020). Data Science Workbench.

Figure 1. Classification of central vascular anatomy into 4 groups and 2 sub groups as follows:

Type 1: ileocolic artery crosses anteriorly to the superior mesenteric vein, jejunal vein crosses anteriorly to the superior mesenteric artery

Type 2: ileocolic artery crosses anteriorly to the superior mesenteric vein, jejunal vein crosses posteriorly to the superior mesenteric artery

Type 3: ileocolic artery crosses posteriorly to the superior mesenteric vein, jejunal vein crosses posteriorly to the superior mesenteric artery

Type 4a: ileocolic artery crosses posteriorly to the superior mesenteric vein, jejunal vein crosses anteriorly to the superior mesenteric artery concealing the ileocolic artery origin

Type 4b: ileocolic artery crosses posteriorly to the superior mesenteric vein, jejunal vein crosses anteriorly so as not to conceal the ileocolic artery

MCA - middle colic artery, GTH - gastroduodenal trunk of Henle, JV - jejunal vein, ICV - ileocolic vein, ICA - ileocolic artery.

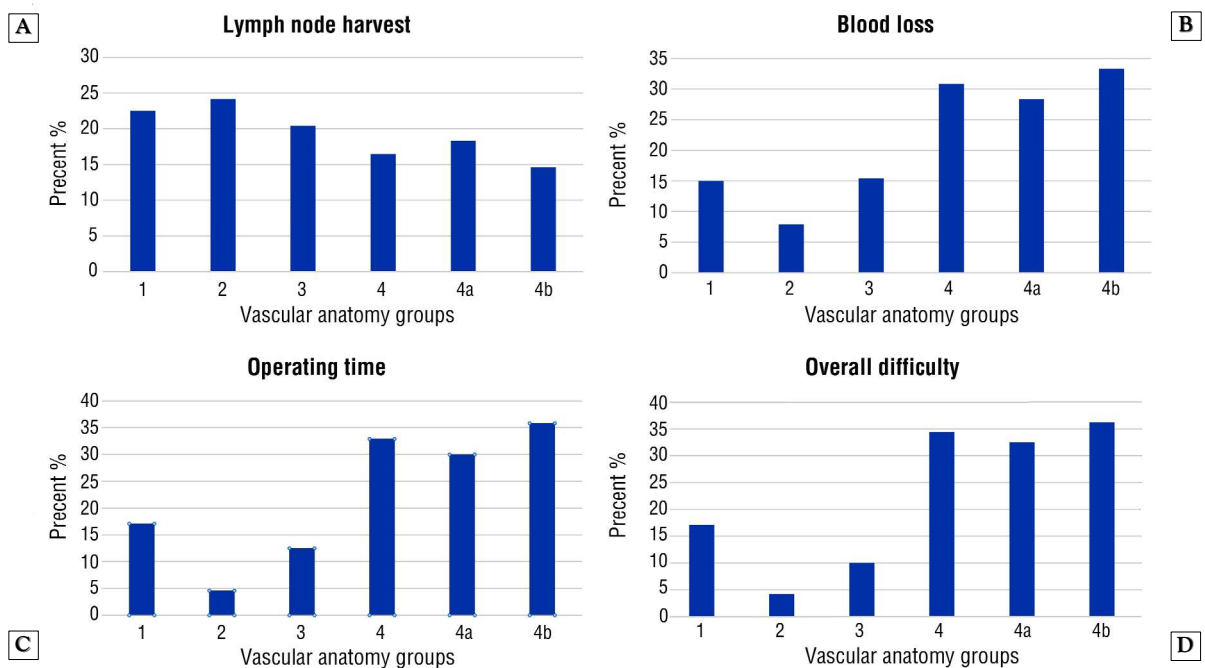
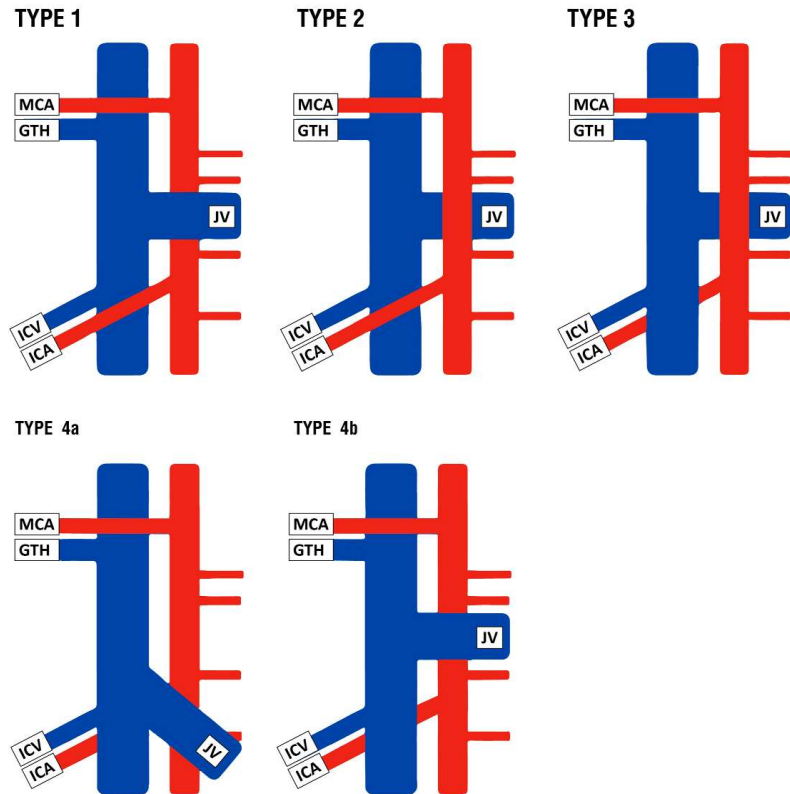


Figure 2. Results of the survey among surgeons. Values are presented as mean percentages of the overall scores given to each anatomy group. (A) Demonstrates longest operating times expected in anatomy group 4, especially type 4b. (B) Demonstrates highest blood expected in anatomy group 4, especially type 4b. (C) Demonstrates slightly lower lymph node yield expected in anatomy group 4, especially type 4b. (D) Demonstrates the assessment of difficulty highest in anatomy group 4, especially type 4b.

Results

All 12 invited surgeons replied to the survey, the results are summarized in *Fig. 2*.

Operating time

There was a high degree of agreement between the surgeons when operating time was concerned, none of the participants considered that there would not be a difference between the groups (0 of 12 surgeons). Two thirds of the participants (8 of 12) expected type 2 anatomy to be least time consuming while 11 of 12 indicated anatomy group 4 to be the most time consuming. Of these 4 of 11 indicated type 4a and 7 of 11 type 4b as most time consuming.

Blood loss

Only 1 of 12 surgeons did not expect a difference in blood loss between the anatomy groups. Five of 12 surgeons expected low blood loss in group 2 anatomy patients while most surgeons (10 of 12) expected higher blood loss in group 4 anatomy patients (3 of 10 type 4a and 7 of 10 type 4b).

Lymph node yield

Only 3 of 12 surgeons expected no differences in the D3 lymph node yield between the vascular anatomy groups. This means 9 surgeons expected a difference. Three surgeons anticipated that group 2 would generate the highest while 2 surgeons expected the lowest lymph node yield in anatomy group 4.

Level of difficulty

None of the surgeons (0 of 12) expected surgery to be equally challenging among the anatomy groups. Two thirds (8 of 12) perceived group 2 as the least challenging while the majority (10 of 12) experienced group 4 (2 of 10 in type 4a and 8 of 10 in type 4b) as the most difficult.

The Friedman ANOVA and Kendall Coefficient of Concordance gave evidence that there was a highly significant difference between the analyzed groups, concerning the Degree of difficulty, Blood loss and Operating

time (all three $p < 0.01$), while there was no difference for the Lymph node yield ($p = 0.43$).

Discussion

When comparing the results from the previous trial (8) to the results of this study some discordance can be found. The survey suggested higher differences in operating time and blood loss between the groups and no difference in lymph node counts (a tendency towards a lower D3 volume lymph node yield expected by surgeons in anatomy group 4 due to the complicated anatomy is noted). Results from the previous study prove using the LSD post-hoc test that patients with anatomy type 4b require statically longer operation times (mean difference 30min)(8). This means that the surgeons' expectations regarding operation time were shown to be accurate only for group 4b. For blood loss and lymph nodes harvested no significant difference was shown. The leveling of differences between the groups can easily be explained through the preoperative planning and the lack of the "surprise factor" at surgery, since all surgeons were aware of the vascular anatomy in all patients before surgery.

As far as lymph node harvest is concerned some surgeons expected higher numbers in group 2 anatomy, in this way reflecting the impression that a most favorable anatomy group in the survey can lead to more complete lymphadenectomy. The results, however, imply that the number of lymph nodes harvested does not depend on the individual vascular anatomy.

One drawback of the study is inter-rater reliability, as the parameters are measured using a survey. The numbers used in the survey reflect the surgeons' subjective assessment of the level of difficulty. Another limitation is that the number of surgeons including patients in the different anatomical groups are uneven. There was a comparably lower number in group 1, this weakens the reliability when we compare expectations against results from the previous trial.

All surgeons in this study used a 3D

roadmap of the vascular anatomy before rating the expected difficulty of the procedure. Expectations can be a limitation - for example negative expectations for a procedure might negatively impact the execution.

A strength of the study is that all the surgeons responded to the survey. This ensured high ecological validity (10) in that the sample of surgeons studied was representative of the total surgeon population. The extended mesenterectomy is restricted to highly specialized tertiary centers. In order to decrease the inter-rater reliability, the surgeons were from multiple centers and received the same training. Another strength is that the 3D reconstruction was performed by only one person, which reduces the probability of random errors in making the 3D roadmap.

Even though literature shows that obesity and previous surgery can increase operation time and blood loss, in the article used for comparison the four vascular groups were comparable for BMI and previous abdominal surgery. This allows us to draw the conclusion on the effect of preoperative awareness of the patients' individual anatomy (the 3D roadmap).

Conclusion

This study shows that using a preoperative individual vascular roadmap at surgery evens out surgeons expectations in operation time, blood loss, lymph node harvest and difficulty. Comparing these expectations to

the previously published data shows that operating time in one anatomy group was the only factor where these expectations were met, and using a preoperative 3D roadmap evens out the differences in difficulty.

Conflict of Interest

The authors have no Conflict of Interest.

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