Ideal level of ligation of the inferior mesenteric artery.
An old debate for a current surgical approach

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AIM: *The ideal level of ligation of the inferior mesenteric artery (IMA) during resection for colorectal cancer is still controversial. The aim of this study was to demonstrate the real advantages and, above all, the adequacy of oncological staging after a low ligation of the IMA with additional LN retrieval in patients undergoing surgery for colorectal cancer.*
MATERIALS AND METHODS*: Between January 2013 and December 2020, 157 patients who underwent curative resection of a primary colorectal tumor were retrospectively included: 64 patients underwent high ligation of the IMA and 93 patients underwent low ligation of the IMA with additional LN retrieval.*
Results - Mean number of lymphnodes harvested (the median number of harvested nodes was 16.2 in "high ligation" group vs 15.4 in "low ligation" group), operation time (272 minutes vs 293 minutes), intraoperative blood loss (40 cc vs 53 cc) and recovery time (median postoperative hospitalization was 6.4 days in both groups) were not significantly different between the groups.
DISCUSSION: *High ligation of the IMA preserves an adequate length of the colon to perform a successful anastomosis and facilitates apical LN dissection. However, it may be associated with an increased risk of anastomotic leakage. Low ligation of the IMA is less invasive and it is associated with a better preservation of genitourinary function and, futhermore, with an accurate oncological clearance.*
CONCLUSION: *Low ligation of the IMA with additional LN retrieval might be an oncologically safe and less invasive procedure in the surgical management of patients with colorectal cancer.*

KEY WORDS: Colorectal cancer, Inferior mesenteric artery, Ligation

Materials and Methods

We retrospectively analyzed 157 patients treated for recto-sigmoid cancer who were referred to our Surgical Institute, between January 2013 to December 2020.
Patients were divided in two groups, depending on the level of IMA ligation. 93 patients, who underwent low ligation of the IMA immediately below the origin of the LCA with lymph nodes dissection of the root of IMA, were included in Group A. The nodes removed at the origin of the vascular trunck were obviously sent separately and addictioned to the anatomical specimen.
Group B consisted of 64 patients which underwent high ligation of the IMA.
All patients underwent laparoscopic elective surgery, by the same surgical equipe.
The two groups were homogeneous according to age, sex, demographic characteristics and clinical stage. The female/male ratio was 94/63, with a median BMI of 25.8.
Exclusion criteria were distant metastases, previous colorectal surgery, syncronous or metacronous neoplasia, cancer of the lower rectum requiring colo-anal anasto-

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mosis or abdomino-perineal resection, open surgical approach and emergency surgery.
A total of 37 patients (23.5%) with middle-rectal cancer underwent neo adjuvant chemo and radio-therapy.
Medial to lateral dissection of the sigmoid and descending colon was performed along the avascular plane with nerve preservation. IMA's ligature was done immediately below the origin of LCA, previously identified. The removal of lymphnodes that lie along the IMA trunk, from the origin of the LCA to the bifurcation of the superior rectal artery (SRA), is performed medially along the vessel itself, using a harmonic scalpel, ensuring the lymphadenectomy. The inferior mesenteric vein (IMV) was ligated at the origin. IMA high ligation was performed at its origin from the aorta, as usually. Complete colonic splenic flexure mobilization was performed for a tension free anastomosis when necessary. Descending colon was used for the anastomosis. An haemorrhage test of the marginal artery was performed at the planned side of division. Reconstruction was done using an end to end trans-anal stapling anastomosis, according to Knight-Griffen technique. An air leak test was done after reconstruction.
Chi-squared test was used to analyze categorical variables, and P value < 0.005 was considered statistically significant.

Results

All patients were staged according to TNM, since, at least, 12 lympho nodes were always collected, actually the median number of harvested lympho nodes was 16.2 in the high ligation group, and 15.4 in cases of low ligation, without statistical significance.
A complete mobilization of the splenic flexure was done in 60% of cases, to ensure a tension free anastomosis. Similarly, in group A ("low ligation" group) in 3 cases of middle rectal cancer, we had to dissect the LCA after the lymphadenectomy to ensure a tension free anastomosis. We had clinical evidence of 2 cases of anastomotic leak (1.27%), both in the "high ligation" group (3.12%). We had no mortality observed after 60 days from surgery. A loop ileostomy was performed in 35 patients, mainly after neoadjuvant therapy.
The surgical time was 293 (range 179 - 423) minutes in the low ligation group, and of 272 minutes (range 163 - 381) in the group B. The median blood loss was 53 cc (range 31 - 430) in the group A and of 40 cc (range 23 - 72) in the second group. The median postoperative hospital stay was 6.4 days.

Discussion

The debate about the ideal ligation level dates back to 1908, when Miles, first proposed a low ligation of the IMA, while Moynihan proposed the concept of high ligation by its origin from the aorta [3].
In 1959 Dumphy introduced a modified procedure in which, instead of high ligation, performed a low ligation of IMA with dissection of fatty tissues and nodes in the angle between IMA and the aorta [4].
Anastomotic ischemia and increased anastomotic tension are believed to be the major risk factor for the development of an anastomotic leakage [5]. After an high ligation of the IMA, at the emergence from the aorta, perfusion of the proximal colon is only due to marginal arteries like Drummond and Riolano arcades and to the descending branch of the middle colic artery, originating from the superior mesenteric artery. In a quarter of the cases the vascularization is further supported by the presence of the accessory artery of the left corner (accessory middle colic artery) [6,7].
It is anatomically evident that preservation of the LCA ensure a better anastomotic perfusion.
The high ligation is associated to an increased risk of poor colonic stump blood supply when relying on the marginal artery alone, therefore, if this artery is not adequate, a more extended intestinal resection has to be performed, even if it is oncologically unnecessary [8]. We know that in low rectal resection with total mesorectal excision the rectal stump is the area more vulnerable from the circulatory point of view, because the blood flow is particularly poor in the distal rectum, but a good perfusion of the colonic limb could be considered a protective factor against a possible leakage [9]. On the other hand colon ischemia is a real complication of the IMA ligation in aortic surgery, expecially in older patients with atherosclerotic vessels and deficit of the marginal artery at the splenic fle [11].
The risk of poor blood supply to the anastomosis outweigh the oncologic benefit of performing high ligation in the inferior mesenteic artery routinely
Lymph node involvement is recognized as a major prognostic factor in the survival of colorectal cancer, but the extent of lymphadenectomy still remains controversial [11].
From the beginning of colonic and rectal laparoscopic resection manly centers prefer routinely high tie IMA because of its technical care and to ensure adequate length of proximal colon to anastomize [12]. From the surgical point view preserving LCA and dissecting lymphonodes around the origin of IMA is technically demanding and time consuming. The position of the IMV is fickle, in fact it can be running under or above the LCA, so extreme attention should be taken during dissection of the LCA, avoiding troublesome venous damaging.
The anathomical variation in the origin of LCA increases the operational complexity, the branching of the IMA varies among individual patients and an understanding of those variation is essential for the low ligation technique. LCA arose directly from the IMA in 46% of cases, from a common trunck with sigmoid arteries (SA)

in about 24% of patients, from a common trunk including LCA, SA and rectal superior artery (RSA) in 30% of cases [13].

In oncological terms, high tie has been found to enable full lymph nodes dissection and to make a greater contribution to accurate staging [14]. According to the National Cancer Institute of the United States of America, an appropriate proximal lymphatic resection for rectal cancer, without clinical evident node disease is provided by the removal of the blood supply and lymph nodes up to the level of the origin of the primary feeding vessel. For rectal cancer this is the origin of the superior rectal artery which is immediately distal to the offspring of LCA [15]. According to TNM classification, to have an adequate stadiation, are necessary at least 12 nodes. Limited lymph nodes dissection with preservation of IMA may result in a reduced number of harvested nodes, however increasing the number of nodes by dissecting distant free nodes is considered to have no clinical impact. It has been reported that the rate of positive lymph nodes at the root of the IMA is about 4.9% and are often associated with advanced tumor stage, but these nodes have to be considered as distant metastases, having a prognostic role rather than a curative one [16].

Neo adjuvant chemo therapy has also the potential to sterilize microscopic metastases in nodes at the origin of the IMA, undermining the rational of high tie even more. Preservation of LCA and carring out of lymphonodes around the origin of the IMAis widely performed by Japanese Author. Probably high ligation should be recommended in cases of macroscopically suspected lymphatic metastases [17].

On the other hand the high ligation is more likely to damage the nerve plexus around the IMA root, determining autonomic nervous system disorders with impact on urinary and sexual function [18]. The paraortic trunk originates from the mesenteric plexus and descendes along the aorta forming the superior hypogastric plexus, so in high tie it is important to avoid autonomous nerve damage [19]. While in low ligation a lymphadenectomy extended to the origin of the inferior mesenteric artery provides data on the disease involvement of apical nodes, archiving a careful disease staging. Arterial ligation far from the hypogastric plexus could led to preserving pelvic autonomic function, giving a better quality of patient's life [20].

Conclusions

In our experience the low ligation of the inferior mesenteric artery with lymphadenectomy is a safe and effective procedure in the laparoscopic treatment of rectosigmoid carcinoma. This technique is particularly indicated in elderly patients to maintain a good vascular flow towards the anastomosis. Low tie with lymphadenectomy is anatomically less invasive and it's not inferior to high tie from the prognostic point of view; this technique is a good compromise between vascular preservation and extended lymph nodes dissection.

There is the possibility that high ligation is preferable for anastomotic tension, while low ligation is preferable regarding post operative bowel, urinary and sexual function.

Riassunto

Il livello ideale di legatura dell'arteria mesenterica inferiore (IMA) durante la resezione per il cancro del colon-retto è ancora controverso. Lo scopo di questo studio è stato quello di dimostrare i reali vantaggi e, soprattutto, l'adeguatezza della stadiazione oncologica dopo una bassa legatura dell'IMA con recupero aggiuntivo di LN in pazienti sottoposti ad intervento chirurgico per cancro del colon-retto.

Materiali e metodi: Tra gennaio 2013 e dicembre 2020, sono stati inclusi retrospettivamente 157 pazienti sottoposti a resezione curativa di un tumore colorettale primitivo: 64 pazienti sono stati sottoposti a legatura elevata dell'IMA e 93 pazienti sono stati sottoposti a legatura bassa dell'IMA con recupero di LN aggiuntivo.

Risultati: Numero medio di linfonodi prelevati (il numero mediano di linfonodi prelevati era 16,2 nel gruppo "legatura alta" vs 15,4 nel gruppo "legatura bassa"), tempo di intervento (272 minuti vs 293 minuti), perdita ematica intraoperatoria (40 cc vs 53 cc) e il tempo di recupero (l'ospedalizzazione postoperatoria mediana è stata di 6,4 giorni in entrambi i gruppi) non erano significativamente differenti tra i gruppi.

Discussione: La legatura alta dell'IMA preserva una lunghezza adeguata del colon per eseguire un'anastomosi di successo e facilita la dissezione linfonodale. Tuttavia, può essere associato ad un aumentato rischio di deiscenze anastomotiche. La legatura bassa dell'IMA è meno invasiva ed è associata ad una migliore conservazione della funzione genito-urinaria e, inoltre, ad un'accurata clearance oncologica.

Conclusione: La legatura bassa dell'IMA con recupero aggiuntivo di LN potrebbe essere una procedura oncologicamente sicura e meno invasiva nella gestione chirurgica dei pazienti con cancro del colon-retto.

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Commento e Commentary

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Il problema di anatomia chirurgica che riguarda l'arteria mesenterica inferiore ed il livello della sua allacciatura e sezione nella chirurgia demolitiva del colon sinistro va analizzato alla luce di più di un fattore.
Innanzitutto bisogna distinguere se la resezione da effettuare riguarda il colon discendente, comprensivo del sigma, oppure se si tratta di una resezione anteriore del retto. Si ricorda a questo proposito che i rami terminali dell'AMI, dopo l'origine delle arterie sigmoidee, sono le due arterie emorroidarie superiori, che si distribuiscono al retto. Pertanto se la resezione del colon sinistro riguarda una neoplasia del sigma, la conservazione del retto sconsiglierebbe la resezione dell'AMI per non aumentare i rischi di una deiscenza anastomotica. In tal caso esistono due alternative: 1) o sacrificare anche la porzione intraperitoneale del retto includendola nella resezione, lasciando la vascolarizzazione del retto sottoperitoneale affidata alle arterie emorroidari medie ed inferiori, direttamente o mediatamente dipendenti dall'arteria iliaca interna; 2) preparare anatomicamente, per via sottoavventiziale, tutta l'AMI fino ad eliminare tutte le arterie sigmoidee, lasciando l'arteria scheletrizzata ad irrorare il retto intraperitoneale. In tal caso la linfoadenectomia dell'intera arteria sarebbe assicurata proprio dalla sua scheletrizzazione sottoavventizale.
Se invece la resezione riguarda il retto, e dunque la sua resezione scenderà ad almeno 4 cm al di sotto del limite inferiore macroscopico della neoplasia, l'AMI sarà certamente sacrificata, ma non necessariamente dalla suo origine. Per poter preservare la vascolarizzazione del colon trasverso, dell'angolo splenico del colon e del tratto prossimale del discendente, per non dover realizzare un'anastomosi colon-rettale in tensione, è opportuno che l'AMI venga sezionata al di sotto dell'emergenza dell'a. colica superiore. Infatti, anche se esistesse un'arcata di Riolano valida, è solo la conservazione dell'arteria colica superiore a garantire la migliore vascolarizzazione possibile del tratto prossimale del colon discendente che non verrà resecato.
Per una buona linfadenectomia di tipo oncologico, la scheletrizzazione sottoavventiziale del tratto dell'AMI fino all'emergenza dell'arteria colica superiore è in grado di garantirla.

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The problem of surgical anatomy concerning the inferior mesenteric artery and the level of its lacing and section in the demolition surgery of the left colon must be analyzed in the light of more than one factor.
First of all, it is necessary to distinguish whether the resection to be performed concerns the descending colon, including the sigmoid, or whether it is an anterior resection of the rectum. In this regard, it should be remembered that the terminal branches of the AMI, after the origin of the sigmoid arteries, are the two upper hemorrhoidal arteries, which are distributed to the rectum. Therefore, if the resection of the left colon concerns a neoplasm of the sigma, the preservation of the rectum would advise against resection of the AMI in order not to increase the risks of an anastomotic dehiscence. In this case there are two alternatives: 1) either sacrifice the intraperitoneal portion of the rectum by including it in the resection, leaving the vascularization of the subperitoneal rectum entrusted to the middle and lower hemorrhoidal arteries, directly or mediately dependent on the internal iliac artery; 2) anatomically prepare, subadventitially, the entire AMI until all the sigmoid arteries are eliminated, leaving the skeletonized artery to supply the intraperitoneal rectum. In this case, the lymphadenectomy of the entire artery would be ensured precisely by its sub-adventital skeletonization.
If, on the other hand, the resection concerns the rectum, and therefore its resection will drop to at least 4 cm below the macroscopic lower limit of the neoplasm, the AMI will certainly be sacrificed, but not necessarily from its origin. In order to preserve the vascularization of the transverse colon, the splenic angle of the colon and the proximal tract of the descendant, in order not to have to perform a colorectal anastomosis in tension, it is advisable that the AMI is sectioned below the emergence of the superior colic artery. In fact, even if there was a valid Riolano arch, it is only the preservation of the superior colonic artery that guarantees the best possible vascularization of the proximal tract of the descending colon that will not be resected.
For a good oncological lymphadenectomy, the subadventitial skeletonization of the AMI tract up to the emergence of the superior colic artery is able to guarantee it.