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ÉVALUATION D'UNE NOUVELLE APPROCHE CHIRURGICALE DE L'APPENDICITE CHEZ L'ENFANT :

LA LAPAROSCOPIE PAR INCISION TRANS-OMBILICALE UNIQUE

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SERMENT D'HIPPOCRATE

En présence des Maîtres de cette Faculté,
de mes chers condisciples
et selon la tradition d'Hippocrate,
je promets et je jure d'être fidèle aux lois de l'honneur
et de la probité dans l'exercice de la Médecine.

Je donnerai mes soins gratuits à l'indigent,
et n'exigerai jamais un salaire au-dessus de mon travail.

Admis dans l'intérieur des maisons, mes yeux
ne verront pas ce qui s'y passe, ma langue taira
les secrets qui me seront confiés et mon état ne servira pas
à corrompre les mœurs ni à favoriser le crime.

Respectueux et reconnaissant envers mes Maîtres,
je rendrai à leurs enfants
l'instruction que j'ai reçue de leurs pères.

Que les hommes m'accordent leur estime
si je suis fidèle à mes promesses.
Que je sois couvert d'opprobre
et méprisé de mes confrères
si j'y manque.

RÉSUMÉ – ABSTRACT

ÉVALUATION D'UNE NOUVELLE APPROCHE CHIRURGICALE DE L'APPENDICITE CHEZ L'ENFANT :

LA LAPAROSCOPIE PAR INCISION TRANS-OMBILICALE UNIQUE

Résumé

L'appendicite aigue est la cause la plus fréquente d'hospitalisation pour syndrome douloureux abdominal aigu. Elle représente près de 30% des interventions de chirurgie digestive avec une incidence de 1.39/1000 habitants en France en 2009 tout âge confondu. Dans sa forme compliquée, perforation jusqu'à la péritonite généralisée, elle peut mettre en jeu le pronostic vital avec un taux de mortalité de 1.5 à 5% contre 0.1% dans les formes non compliquées.

Chez l'enfant, c'est l'une des urgences chirurgicales les plus courantes touchant 0.3% des enfants entre 0 et 15 ans. Son traitement reste avant tout chirurgical.

Dans un souci constant d'amélioration des bénéfices apportés aux patients, de nouvelles techniques prometteuses ont émergé au cours des cinquante dernières années, détrônant possiblement la technique de référence par voie ouverte décrite dès 1894 par le chirurgien américain Charles McBurney.

La première partie retrace l'histoire de l'appendicectomie jusqu'à l'approche laparoscopique conventionnelle utilisant trois trocarts, et plus récemment l'utilisation de la voie trans-ombilicale unique.

Dans une deuxième partie, nous abordons la faisabilité de cette technique en chirurgie pédiatrique avec une étude préliminaire prospective monocentrique menée pour l'ensemble des appendicites diagnostiquées (simples ou compliquées).

Ensuite, la troisième partie compare, via une seconde étude prospective randomisée, les deux approches laparoscopiques, conventionnelle et à incision trans-ombilicale unique, pour la prise en charge chirurgicale de l'appendicite simple uniquement.

Enfin, les résultats cosmétiques des deux techniques à long terme sont débattus via une enquête prospective.

Mots clés : Enfants. Appendicectomie. Laparoscopie. Incision trans-ombilicale unique. Cosmétique

EVALUATION OF A NEW SURGICAL APPROACH OF APPENDICITIS IN CHILDREN: TRANS-UMBILICAL SINGLE-INCISION LAPAROSCOPY

Abstract

Acute appendicitis is the most frequent cause of hospitalization for acute abdominal pain. It represents nearly 30% of digestive surgery procedures with an incidence of 1.39/1000 inhabitants in France in 2009, all ages considered. In its complicated form, perforation to generalized peritonitis, it can be life-threatening with a mortality rate of 1.5 to 5% compared to 0.1% in the uncomplicated forms.

In children, it is one of the most common surgical emergencies affecting 0.3% of children between 0 and 15 years old. Treatment remains above all surgical.

In a constant concern to improve patients' benefits, promising new techniques have emerged over the past fifty years, possibly dethroning the Gold Standard open technique described in 1894 by the American surgeon Charles McBurney.

The first part of this work reports the history of appendectomy up to the conventional laparoscopic approach using three trocars, and more recently the use of the trans-umbilical single-incision.

In a second chapter, we discuss the feasibility of this technique in pediatric surgery with a single-center prospective preliminary study carried out for all diagnosed appendicitis (simple or complicated).

Then, the third part compares, through a second prospective randomized study, the laparoscopic approach of trans-umbilical single-incision to conventional laparoscopy for the surgical management of simple appendicitis only.

Finally, the cosmetic long term results of the two techniques are debated by means of a prospective survey.

Key words: Children. Appendectomy. Laparoscopy. Trans-umbilical single-incision. Cosmesis

TABLE DES MATIÈRES

INTRODUCTION

L'appendicite aigue est l'une des urgences chirurgicales les plus courantes rencontrées en Chirurgie Pédiatrique, touchant 0.3% des enfants entre 0 et 15 ans [1]. L'appendicectomie représente près de 30% des interventions de chirurgie digestive avec une incidence de 1.39/1000 habitants en France en 2009 tout âge confondu [2]. Son incidence au cours d'une vie est estimée à 8% [3,4]. Dans sa forme compliquée, perforation allant jusqu'à la péritonite généralisée, elle peut mettre en jeu le pronostic vital avec un taux de mortalité de 1.5 à 5 % contre 0.1 % rapporté dans les formes non compliquées. On retrouve parmi les cas pédiatriques, environ un quart d'appendicites compliquées.

Revendiqué depuis la fin du XIXème siècle, son traitement reste avant tout chirurgical. L'approche par voie ouverte, décrite dès 1894 par le chirurgien américain Charles McBurney, était considérée comme technique de référence pendant plus de 100 ans [5].

Dans un souci constant d'amélioration des bénéfices apportés aux patients, la chirurgie mini-invasive s'est développée bousculant les codes de la chirurgie « traditionnelle ». De nouvelles techniques prometteuses ont émergé au cours des cinquante dernières années, détrônant possiblement le Gold Standard de la voie ouverte.

Dans une première partie nous retracerons **l'histoire de l'appendicectomie** et l'émergence de nouvelles approches telle que la laparoscopie conventionnelle conduisant aujourd'hui à s'intéresser à l'abord laparoscopique par incision trans-ombilicale unique.

Dans une deuxième partie nous aborderons la **faisabilité** de cette technique en chirurgie pédiatrique selon une **étude préliminaire** réalisée quel que soit le type d'appendicite diagnostiquée. Il s'agit d'une étude **comparative prospective monocentrique** menée pour les patients avec diagnostic d'appendicite simple ou compliquée.

Ensuite, la troisième partie visera à comparer l'approche laparoscopique à incision unique à la laparoscopie conventionnelle pour l'appendicectomie dans les **cas non compliqués** diagnostiqués au sein de notre établissement au moyen d'une **deuxième étude comparative prospective randomisée**.

Enfin, la dernière partie de ce travail rapportera les **résultats cosmétiques** des deux techniques à long terme via une **troisième étude comparative** menée après maturation des cicatrices.

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CHAPITRE I

HISTOIRE DE L'APPENDICECTOMIE

CHEZ L'ENFANT

I - De la naissance de l'appendicite à l'appendicectomie

L'appendice a été représenté pour la toute première fois par **Léonard De Vinci** en 1492 mais ses dessins ne furent publiés que plusieurs siècles plus tard *(Image 1).* C'est à l'anatomiste Italien **Berengario da Carpi** que revient le crédit de la première description anatomique de l'appendice comme une « petite cavité vide à l'extrémité du caecum » en 1521, illustrée par la suite dans l'ouvrage *De Humani Corporis Fabrica* en 1543 de Andreas Vesalius [1].

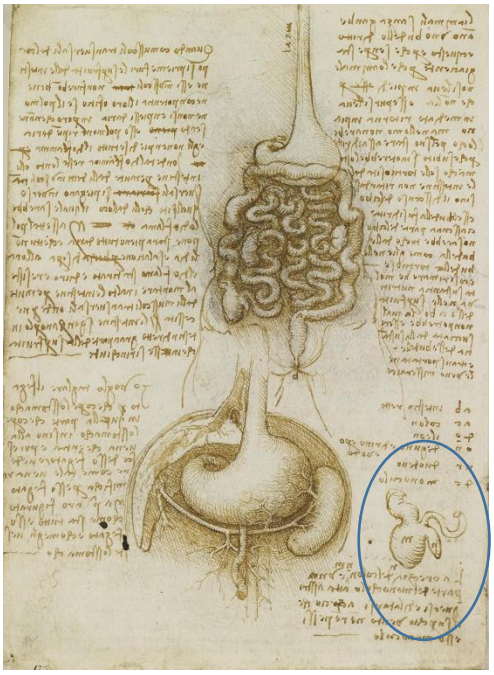

***Image 1** : Appendice selon Léonard De Vinci*

Légué à Francesco Melzi; acheté auprès de ses héritiers par Pompeo Leoni, vers 1582-90; puis acquis par Thomas Howard, 14e comte d'Arundel, en 1630; probablement acquis par Charles II; Collection royale en 1690
https://www.rct.uk/collection/919031/recto-the-gastrointestinal-tract-and-the-bladder-verso-the-gastrointestinal-tract

Différents récits post-mortem d'anomalies appendiculaires ont été rapportés pendant plus de 200 ans sans néanmoins identifier l'appendice comme source de la pathologie. En effet, le diagnostic de **pérityphlite** restera le plus décrit jusqu'à la fin des années 1880 [2]. Cependant, la **première appendicectomie** chez **l'enfant** fût réalisée par **Claudius Amyand**, en **1735** à Londres, chez un enfant de 11 ans dont l'indication ne reposait pas sur le diagnostic d'appendicite aigue mais sur la cure d'une hernie inguinale congénitale suppurant depuis 1 mois. Amyand retrouva en fait un appendice perforé par une épingle avalée par l'enfant [3].

La première définition **d'appendicite aigue** chez l'enfant date de 1813 et c'est avec la publication de **Reginald Fitz** en **1886** que le diagnostic de pérityphlite sera corrigé en celui **d'appendicite aigue** résolvant ainsi l'énigme des douleurs du quadrant inférieur droit de l'abdomen [4,5]. Quelques années plus tard, en **1889, Charles McBurney** décrivit un ensemble de symptômes, connus de nos jours comme correspondant classiquement au tableau d'appendicite aigue, et notamment la douleur au fameux **point de McBurney** [6] *(Image 2)*.

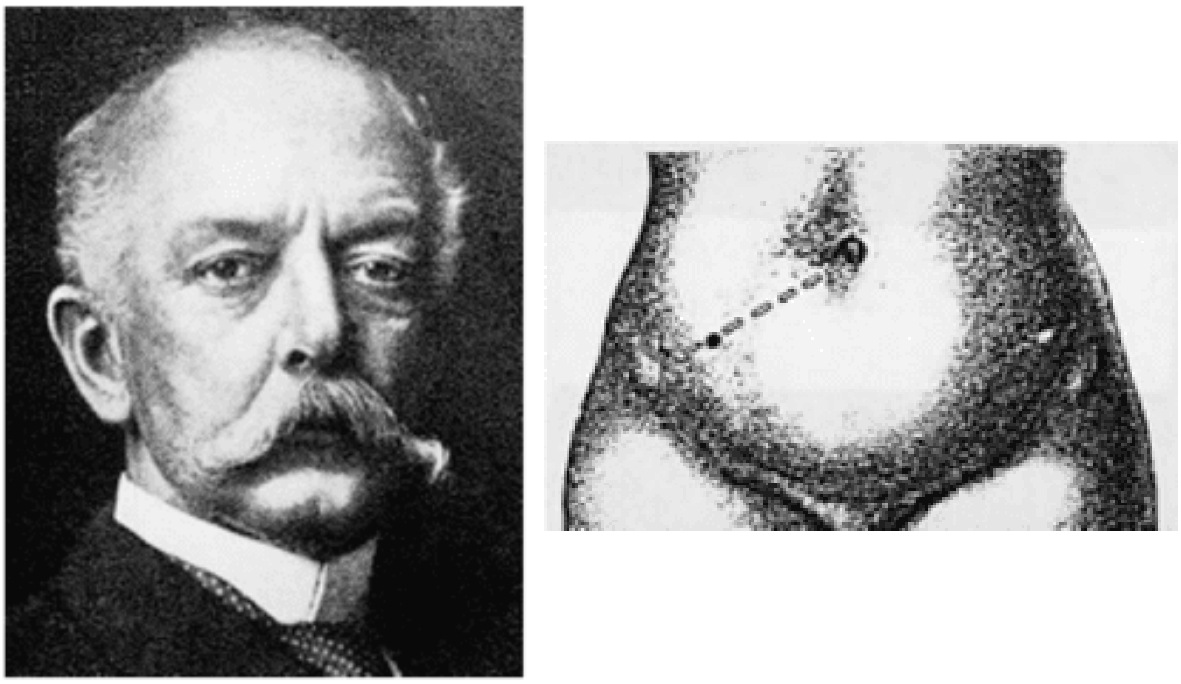

***Image 2** : Charles Herber McBurney (1845-1913) et le point de McBurney [7]*

L'appendicectomie devint alors le **traitement de choix** de l'appendicite aigue et plusieurs cas furent décrits dans les années 1880 chez l'enfant, par Lawson Tait en Angleterre ou Abraham Groves au Canada [5]. Une insistance particulière initiale fût portée sur l'importance de ne pas différer l'intervention devant les faibles taux de mortalité rapportés et le risque de péritonite [5,6,8]. Cette insistance était d'autant plus marquée devant le diagnostic d'appendicite aigue chez **l'enfant** de sorte que même les défenseurs du traitement conservateur estimaient que les enfants étaient une exception et devaient bénéficier du traitement chirurgical sans délai [9].

Dans les années qui suivirent, au **début du XXème siècle**, l'accent fût mis sur le développement et la maîtrise de la technique chirurgicale. La deuxième moitié du XXème siècle fût, elle, marquée par l'avancement des modalités associées à la prise en charge chirurgicale de l'appendicite à la fois diagnostiques (protocoles, imagerie) et thérapeutiques avec l'ajout de l'antibiothérapie dans les cas compliqués à partir des années 1940 [10,11]. L'antibiothérapie dans la prise en charge de l'appendicite aigue (rôle, durée, moment) faisant toujours débat depuis son introduction, la question ne sera pas abordée dans le présent travail tant elle est vaste [12].

L'objectif de la fin du siècle pour les chirurgiens pédiatres, à l'instar de Ravitch, était alors d'effectuer le bon diagnostic d'appendicite, afin d'intervenir avant la survenue de complication sans passer à côté du diagnostic et sans pour autant accumuler les appendicectomies blanches [13].

Une nouvelle avancée technique avec l'introduction de **l'appendicectomie laparoscopique** par le gynécologue **Kurt Semm** en **1982** s'inscrit dans cette lignée et va venir bousculer les codes de la prise en charge chirurgicale de l'appendicite aigue [14].

II - L'appendicectomie chez l'enfant : d'hier à aujourd'hui

A - Appendicectomie par voie ouverte : technique princeps

Charles McBurney, chirurgien New-Yorkais *(Image 3)*, décrivit la technique éponyme, bien connue à l'heure actuelle, de l'incision dans le quadrant inférieur droit de l'abdomen avec discision des muscles. Il est à noter que cette technique fût utilisée pour la première fois par un chirurgien de Chicago, **Lewis McArthur,** qui ne parvint pas à publier ses travaux avant McBurney [15]. Ce dernier reconnaîtra toutefois la primeur à McArthur mais la voie d'abord conserva son nom [5] [16].

***Image 3** : Dr McBurney opérant à l'Hôpital Roosevelt en 1901*

Archives de "American College of Surgeons"
https://bulletin.facs.org/2016/01/dr-charles-mcburney-a-pioneer-in-the-surgical-treatment-of-appendicitis/

La technique exposée par McBurney en **1894** reste toujours d'actualité et consiste en une incision oblique d'environ 5 cm située dans la fosse iliaque droite, croisant une ligne droite tracée entre l'épine iliaque antéro-supérieure droite et l'ombilic à la jonction tiers externe et deux tiers internes. L'aponévrose du muscle oblique externe est ensuite sectionnée et les fibres de celui-ci sont séparées sans section. On réalise alors une discision des fibres des

muscles oblique interne et transverse puis une section du fascia transversalis et ouverture du péritoine. On aperçoit alors le caecum qui est mobilisé afin de laisser apparaître l'appendice qui est alors extériorisé. Le méso appendiculaire est ligaturé et sectionné et l'appendice est ensuite sectionné à son tour après ligature à sa base laissant un moignon appendiculaire [16,17]. Après l'appendicectomie, qui n'est d'ailleurs pas détaillée dans cet article de 1894, le péritoine est suturé, les fibres musculaires transverses et obliques internes sont rapprochées par des points « fins », l'aponévrose de l'oblique externe est suturée de même que la peau, restaurant ainsi l'aspect grillagé de la paroi abdominale qui lui confère sa solidité [18].

Les avantages rapportés par McBurney, déjà à l'époque, étaient la solidité de la réparation (et donc la diminution des hernies postopératoires), l'absence de saignement lors de la dissection et l'absence quasi totale de douleur devant la séparation des muscles sans section.

D'autres incisions sont utilisées, telles que la modification de Lanz [5,19], l'incision transverse selon Rocky-Davis [16] ou encore certaines incisions étendues [20], avec ou sans épargne musculaire, induisant alors une douleur plus intense et une récupération plus longue *(Image 4)*.

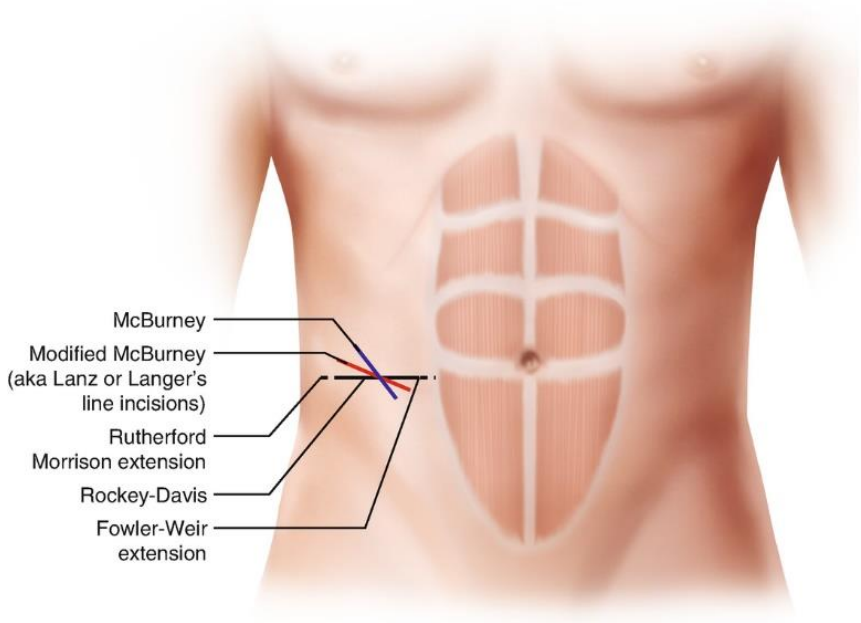

***Image 4** : Différentes incisions de l'appendicectomie par voie ouverte*

D'après Nasser H., Karamanos E. (2020) Open Appendectomy. In: Karamanos E. (eds) Common Surgeries Made Easy. Springer, Cham. https://doi.org/10.1007/978-3-030-41350-7_23

Cette approche apporte également d'autres avantages, tels que sa simplicité en terme de matériel nécessaire, son coût abordable, sa reproductibilité, qui lui ont conféré sa notoriété pendant plus de **120 ans**.

Cependant, la voie ouverte présente des **désavantages** : pas d'exploration de toute la cavité intrapéritonéale, et donc pas de correction de diagnostic en cas d'erreur (par exemple chez la jeune fille l'exploration des ovaires et du pelvis est difficile par voie ouverte), et une cicatrice abdominale visible. C'est pourquoi l'avancée technique de la fin du XXème siècle vient alors progressivement détourner l'attention de la voie ouverte.

B - Appendicectomie par laparoscopie conventionnelle : nouveau Gold Standard

L'appendicectomie par laparoscopie conventionnelle (*Conventional Laparoscopic Appendectomy en anglais* – ***CLA***), également appelée cœlioscopie et utilisant usuellement 3 trocarts, a été introduite par le gynécologue **Semm** en **1982** [14]. Elle a progressivement supplémenté l'appendicectomie par voie ouverte pour s'imposer plus récemment comme **technique de référence** dans l'appendicite aigue, y compris chez l'enfant [21]. Elle est alors devenue la technique de choix en **routine** dans la plupart des centres [22].

Classiquement, l'appendicectomie par laparoscopie consiste en l'introduction d'un **trocart optique** de 5 ou 10 mm (adapté à l'âge de l'enfant) sous contrôle de la vue, selon la technique de **l'open** cœlioscopie, par une **incision trans-ombilicale** chez l'enfant. L'exploration de l'intégralité de la cavité abdominale est alors réalisée et permet ainsi la **confirmation du diagnostic** d'appendicite aigue. Le pneumopéritoine est insufflé avec des paramètres dépendants de l'âge de l'enfant. Ensuite, deux autres trocarts sont habituellement introduits dans la technique conventionnelle, généralement de 5 mm, leur emplacement variant selon les centres et la position de l'appendice. Dans notre centre, ils sont la plupart du temps mis un en fosse iliaque gauche et l'autre en sus-pubien (la vidange vésicale préopératoire doit avoir bien été effectuée afin de ne pas gêner à la mobilisation des instruments et risquer une perforation vésicale) *(Image 5)*. Le méso appendiculaire est alors repéré et électro-coagulé puis sectionné soit à l'aide d'une bipolaire et de ciseaux, soit à l'aide d'un crochet coagulateur. Une fois la base appendiculaire dégagée jusqu'au caecum, l'appendice est ligaturé à l'aide d'un Endoloop® positionné à sa base. Selon les habitudes, une 2ème ligature est placée environ 1.5 cm au-dessus et l'appendice est sectionné. D'après la technique initialement décrite par Semm, certains chirurgiens continuent d'appliquer de la bétadine sur le moignon appendiculaire, tandis que d'autres électro-coagulent la muqueuse restante. L'appendice est ensuite extrait par l'intermédiaire d'un sac largable via le trocart ombilical après vérification de la bonne hémostase *(Image 5)* [23].

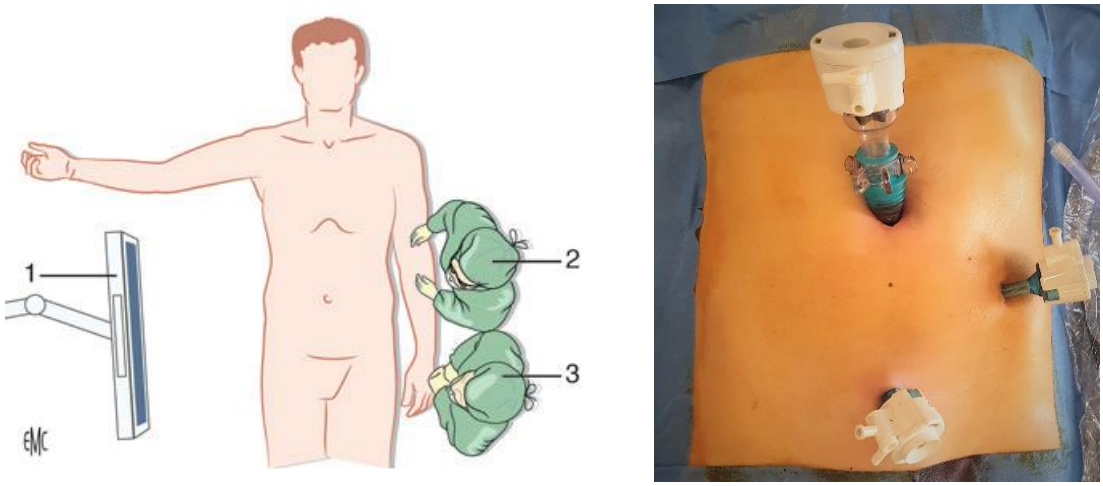

***Image 5** : Appendicectomie par laparoscopie*
Installation standard à gauche [23]
Position des trocarts la plus fréquente dans notre centre à droite

Comme toute nouvelle technique chirurgicale, ses bénéfices par rapport à la voie ouverte resteront controversés pendant une vingtaine d'année [24,25] et ce n'est qu'à partir du début des années 2000 que de plus en plus d'avantages de la laparoscopie chez l'enfant sont mis en avant.

Plusieurs études et méta-analyses rapportent des taux d'abcès de parois moindre en laparoscopie par rapport à la voie ouverte [17,22,26–28] ainsi que moins d'iléus postopératoire [29,30], mais plus d'abcès intrapéritonéaux sont décrits après appendicite perforée [31–33]. Néanmoins, une méta-analyse récente retrouvait des taux d'abcès intra-abdominaux, après appendicite compliquée, similaires quelle que soit la technique utilisée [34].

Beaucoup d'études rapportent également l'utilisation moindre d'antalgiques en post opératoire [22,26], des durées de séjour plus courtes [22,25,35], un retour plus précoce à une activité normale [17,32], mais avec des coûts plus élevés [26].

Son indication apparait également favorisée chez la jeune fille pubère pour ne pas méconnaître une pathologie pelvienne (diagnostic différentiel) et chez l'enfant obèse ou la laparotomie selon McBurney peut s'avérer difficile [17,21].

Le recours à la laparoscopie devient alors croissant [36] car la littérature affirme désormais clairement ses bénéfices sur la voie ouverte et elle s'impose alors comme le nouveau « Gold Standard » pour l'appendicectomie chez l'enfant.

Dans un souci constant d'amélioration des bénéfices, sans augmentation des risques pour les patients, et également de diminution des durées de séjours et des coûts, la technique laparoscopique continue d'être affinée pour pousser au maximum la chirurgie mini-invasive.

C - Chirurgie mini-invasive : vers l'absence de cicatrice

Après l'introduction de la laparoscopie pour l'appendicectomie, de nombreuses modifications techniques ont été apportées afin de réduire au maximum le « traumatisme chirurgical » en diminuant le nombre d'incisions dans le but de diminuer la **douleur** post-opératoire, d'offrir un meilleur aspect **cosmétique et de diminuer le risque d'adhérences post-opératoires**.

Plusieurs approches ont été décrites : l'appendicectomie laparoscopique classique dite « IN » ou intra-abdominale (réalisée avec 3 trocarts et complètement intra-corporelle) va se voir remplacer par des approches dites « OUT » avec extériorisation de l'appendice par le trocart optique, plus ou moins aidé d'un trocart supplémentaire et réalisation de l'appendicectomie extra-corporelle, ou encore des approches passant par un orifice ombilical unique. C'est la naissance de l'appendicectomie laparoscopique par **une seule incision ombilicale unique** !

Décrite pour la première fois par Pelosi en 1992 [37] chez l'adulte, elle est rapportée pour la première fois chez l'enfant par Esposito en 1998 [38] mais ce n'est que plusieurs années après que la technique deviendra vraiment populaire.

Il existe **plusieurs types** d'appendicectomies laparoscopiques à incision unique (*Single-Incision Laparoscopic Appendectomy en anglais* - ***SILA***) et donc de nombreuses appellations associées [17,39,40] :

- Techniques **mixtes ou hybrides** ou encore appelée **appendicectomie trans-ombilicale assistée par laparoscopie** (TULAA en anglais): réalisation d'une incision ombilicale unique pour l'introduction d'un optique avec un canal opérateur ou bien d'un optique et d'une pince atraumatique de 5 mm introduite dans le même orifice le long de ce dernier. La cavité abdominale est alors explorée et l'appendice est extériorisé à travers l'ombilic afin de réaliser l'appendicectomie selon la voie ouverte *(Image 6)* [38,41–44]

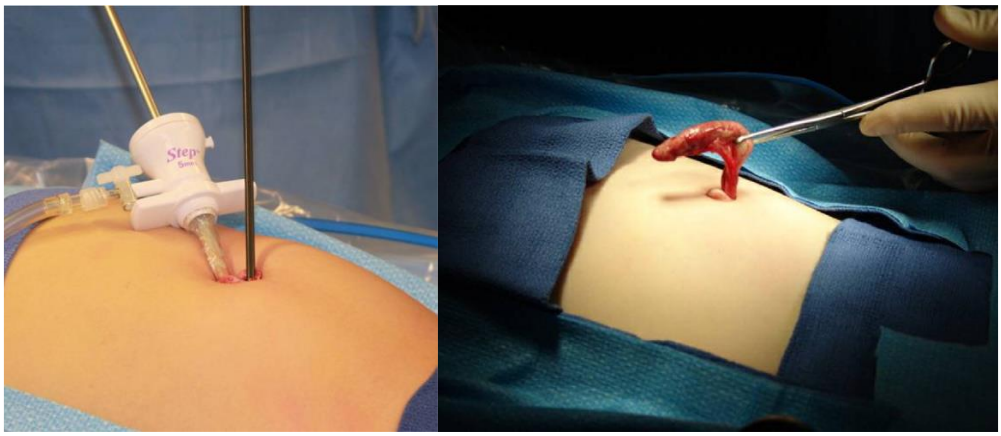

***Image 6** : Technique hybride avec passage à travers différentes incisions aponévrotiques [44]*

- Techniques d'incision unique **assistée** par la mise en place d'une pince en percutané ou encore de dispositifs de sutures endoscopiques permettant d'introduire des fils tracteurs *(Image 7)* [45,46]

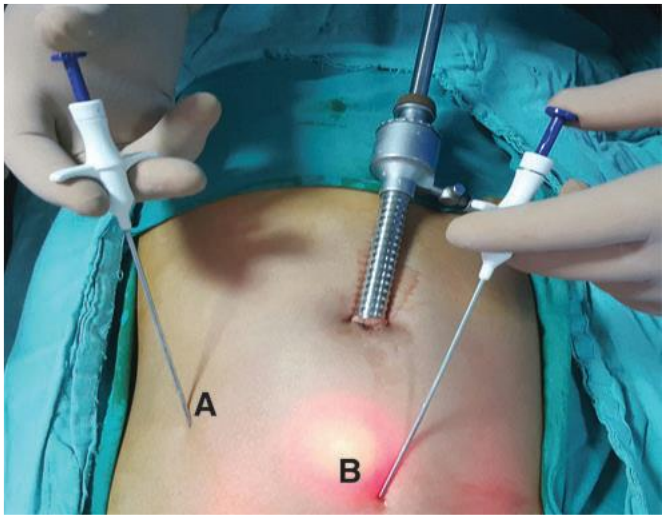

***Image 7** : Dispositifs de sutures endoscopiques percutanés [46]*

- Techniques d'incision unique **non assistée** : introduction d'instruments standards de cœlioscopie ou angulés, directement à travers l'aponévrose ombilicale [47], ou en utilisant un port commercial *(Image 8)* [48,49], ou encore un port fabriqué à partir d'un gant stérile (gloveport) *(Image 9)* [50] où les extrémités de 3 doigts de gant sont coupées afin d'y placer 3 trocarts pour l'introduction d'un optique et de 2 autres instruments, l'appendicectomie en elle-même pouvant être réalisée en intra ou en extra-corporel.

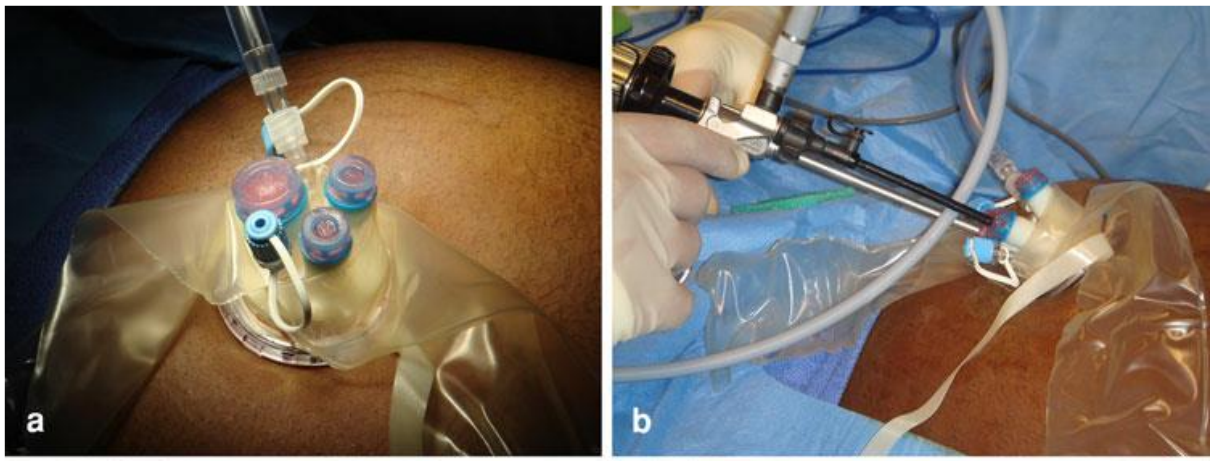

***Image 8** : Ports commerciaux, TriPort® d'Olympus, USA [48]*

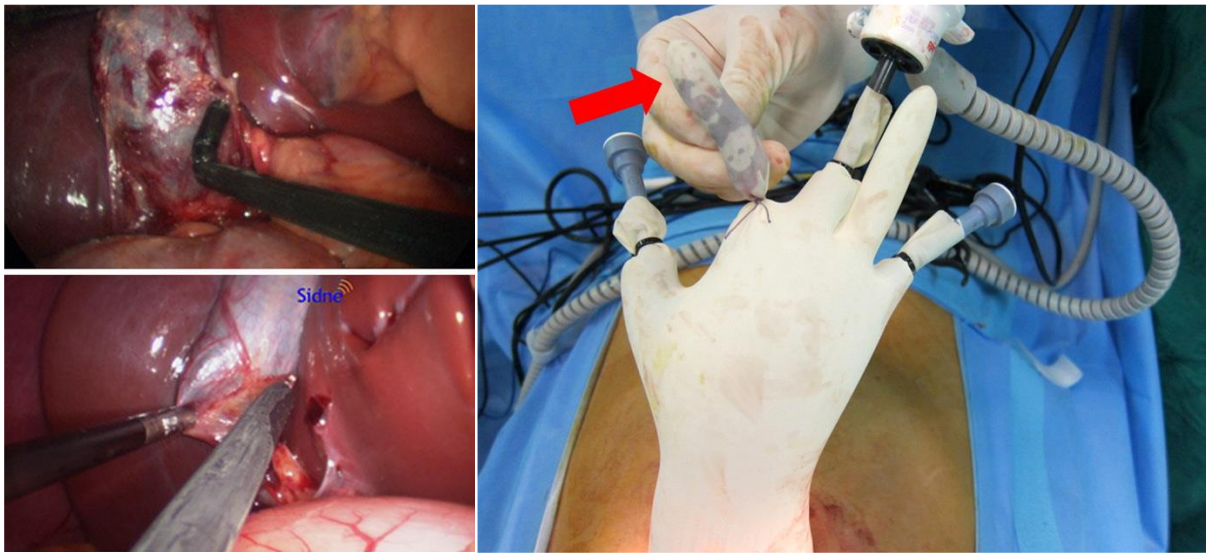

***Image 9** : A gauche, instrument angulé en haut et conventionnel en bas [51]*
A droite, un gloveport [50]

Le point commun de ces techniques à incision unique est l'incision **ombilicale**, le plus souvent trans-ombilicale, d'environ 2cm dans l'ensemble des études, associée à une ou plusieurs incisions aponévrotique(s) selon l'approche choisie. L'ombilic étant un orifice d'origine embryonnaire naturel, la cicatrice est alors cachée en son sein, conférant à cette approche son intérêt majeur.

Depuis une dizaine d'années, de nombreuses études ont évalué et validé sa **faisabilité** chez l'enfant avec une **équivalence** par rapport à la laparoscopie conventionnelle [16,49]. Plus récemment, la littérature tente d'affirmer la supériorité ou non de l'appendicectomie laparoscopique à incision unique (***SILA***) avec des résultats encore controversés à l'heure actuelle.

La **première expérience** rapportée chez l'enfant par Esposito en 1998 [38] consistait en une technique **hybride** et ne décrivait aucune complication notamment d'infection de site opératoire malgré l'extériorisation de l'appendice à travers l'ombilic à l'inverse de Ponsky et al. en 2009 qui rapportèrent des infections ombilicales lors de la réalisation de l'appendicectomie extra-corporelle et aucune lorsque celle-ci était réalisée en intra-corporelle [52].

Les premières études contrôlées randomisées chez l'enfant rapportaient des **temps opératoires plus longs** jusqu'à 15 minutes en moyenne, un **coût plus élevé** et des **difficultés techniques** plus importantes pour la technique à incision unique mais il n'y avait pas de différence en terme de durée de séjour, de taux d'infections du site opératoire ni de retour à une activité habituelle [41,47]. En revanche, selon les études, l'incision unique semblait **plus douloureuse** avec une **consommation postopératoire d'antalgiques plus importante** [41]. Ce résultat était également retrouvé dans la méta-analyse de Jun Gao et al. publiée en 2013 [53]. Plusieurs méta-analyses rapportent aussi des durées opératoires plus longues avec des **résultats similaires sur les complications** postopératoires et la **reprise alimentaire** [53–55].

Toutefois, certains auteurs décrivent des **douleurs moins importantes** dans les 24 premières heures qui suivent une SILA [54]. D'autres études ont retrouvé au contraire des temps opératoires similaires ou plus courts et des **durées de séjours diminuées** dans l'incision unique [56,57].

Sur le plan des complications, Esposito et al. en 2016 décrivent plus d'abcès intra-abdominaux post-opératoires dans la groupe « incision unique » ainsi que des durées d'utilisation d'antalgiques plus longues [58]. Néanmoins, lors d'une analyse de sous-groupe, c'est essentiellement en cas d'appendicites compliquées que le temps opératoire et le score de douleur moyen ainsi que la consommation d'antalgiques et l'incidence d'abcès

intra- abdominaux étaient plus élevés faisant évoquer l'absence d'avantage de l'incision unique en cas d'appendicite compliquée.

L'un des principaux **avantages** crédité à cette technique, et qui en a notamment fait sa popularité, est **l'aspect esthétique**. Décrit comme étant meilleur dans de nombreuses études [40,59], il n'existe que peu d'études comparatives centrées sur ce critère chez l'enfant, et essentiellement à court terme, qui rapportent un bénéfice cosmétique [60,61].

OBJECTIF

Pour résumer, on retrouve une littérature riche concernant l'appendicectomie laparoscopique par incision unique chez l'enfant mais avec une grande hétérogénéité en termes de techniques utilisées ou encore de résultats.

Les **avantages** alloués à cette technique sont :

- la **faisabilité** et sa **sécurité** chez l'enfant quel que soit le type d'appendicite diagnostiquée (simple ou compliquée) [49,58,62],
- sa **facilité de conversion** vers la laparoscopie classique en cas de difficulté [58,63],
- la **diminution** du **nombre d'incisions** atténuant de fait le **risque de plaies** d'autres organes (vessie, tube digestif) ou vaisseaux (épigastriques) lors d'introduction des autres trocarts dans l'approche classique,
- le meilleur aspect cosmétique, bien que les données prospectives comparatives à long-terme soient manquantes chez l'enfant.

Les **désavantages** principaux de cette approche sont les difficultés techniques essentiellement ergonomiques, bien que des astuces aient été rapportées pour s'en affranchir au maximum :

- **triangulation limitée** voire inversée dans les approches intra-corporelles seules,
- **absence de degré de liberté** lors de l'utilisation d'instruments standards non articulés,
- **vision limitée** par une mobilité restreinte,
- **largeur** des **ports commerciaux** considérée comme trop grande pour notre population pédiatrique (notamment pour les jeunes enfants),
- **incision ombilicale** considérée comme **large,** augmentant potentiellement le risque de hernie, risque non rapporté dans la littérature à ce jour [51,64].

Les **aspects encore controversés** à ce jour sont :

- la **durée opératoire**
- la **douleur** postopératoire ainsi que la consommation d'antalgiques
- le taux de **complications** postopératoires
- la durée de **séjour**
- le réel bénéfice **cosmétique**

L'objectif de notre travail était d'évaluer cette technique en comparaison de l'appendicectomie laparoscopique conventionnelle à trois trocarts chez l'enfant.

Pour ne pas introduire de biais, notamment en termes de temps opératoire, nous avons choisi de réaliser l'approche par incision trans-ombilicale unique avec appendicectomie **intra-corporelle seule** (la voie extra-corporelle étant décrite comme plus rapide [65]). Les instruments laparoscopiques utilisés étaient les mêmes pour les deux approches pour ne pas induire de coût supplémentaire ni de biais de durée. De même, nous n'avons pas eu recours aux ports commercialisés mais avons utilisé un gant stérile et un écarteur Alexis® (Applied Medical, USA) de petite taille.

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CHAPITRE II

ÉTUDE PRÉLIMINAIRE

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Laparoscopic one port appendectomy: Evaluation in pediatric surgery

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ABSTRACT

Background: Appendectomy is a well-established surgical procedure in pediatric surgery used in the management of acute appendicitis. With the continuous advancement in the field of minimal invasive surgery, the recent focus is on single incision laparoscopic (SIL) surgery. SILA also goes further in order to decrease pain, improve recovery and enhance patient satisfaction. However, this approach is still not a well-established technique and not widely practiced, especially in pediatric surgery.
Methods: We prospectively recorded the data in our pediatric universitary hospital center since January, 01 2017 to July, 01 2017. Patients included in this study were randomized in two groups: SILA group (managed by one-port laparoscopy, n = 40) and LA group (conventional laparoscopy using three trocars, n = 40).
Results: The mean operative time for SILA was significantly lower. There were no postoperative complications in SILA group. If peritonitis was associated with appendicitis, the operative duration was not significantly different between each group. The duration in recovery room after surgery was significantly lower in SILA group. The morphine consumption was significantly lower for SILA group according to patient weight. SILA is less painful significantly than CLA for the first postoperative 6 h. After, even if SILA appears less painful, difference is not significant. The hospital length of stay was significantly higher in LA than SILA group
Conclusions: SILA procedure for appendectomy appears to be safe and efficient for appendicitis management in children. This technique could be applied in routine as in emergency tome.
Type of study: Prospective comparative study
Level of evidence: II

Appendectomy is a well-established surgical procedure in pediatric surgery used in the management of acute appendicitis.

First described by Amyand [1], the appendectomy procedure was proposed through a right iliac fossa incision by McBurney in 1889 [2]. This technique is also the most popular procedure used for open appendectomy. With minimally invasive techniques area, the laparoscopic appendectomy (LA) was introduced by Semm et al. in 1983 [3]. LA advantages include quicker and less painful recovery, fewer postoperative complications and improved cosmetic results [4]. LA has now become the standard treatment of suspected appendicitis in many centers [5].

With the continuous advancement in the field of minimal invasive surgery, the recent focus is on single incision laparoscopic (SIL) surgery. It was first reported by Pelosi et al. in 1992 [6], and the first SIL appendectomy (SILA) for children was described by Esposito et al. in 1998 but did not seize much attention then. Improvement of technology and the desire of "scarless" surgery made SILA become popular. Recently, because of the progress and evolution of instruments [7,8], single-port laparoscopy has resurged again [9].

SILA also goes further in order to decrease pain, improve recovery and enhance patient satisfaction. However, this approach is still not a well-established technique and not widely practiced, especially in pediatric surgery.

Currently there is heterogeneous set of studies in the literature comparing SILA and conventional LA with small effect sizes and diverse reporting methods. Therefore, a prospective study could help address these issues and other studies' perspective.

1. Material and methods

We prospectively recorded the data in our pediatric universitary hospital center since January, 01 2017 to July, 01 2017. Approval of this study was obtained from the local ethical University committee. Data were recorded anonymously and in accordance with French laws, all children and their parents received appropriate oral and written information regarding the study and data management.

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Patients admitted directly to the pediatric emergency department from their home or transferred from another hospital with a clinical picture of abdominal pain in the right lower quadrant according to appendicitis diagnosis and temperature equal or superior to 37.5 °C were included.

Patients with sepsis or septic shock requiring urgent admission to an intensive care unit were not included.

The diagnosis was made on the clinical symptomatology (localized tenderness and guarding – temperature equal or superior to 37.5 °C in particular), biological (leukocyte count more than 10 G/dL) and ultrasound results.

Ultrasounds were carried out on two ultrasound devices GElogicE9 with a convex probe 2–9 Hz and a high frequency linear probe (9 Hz) by senior radiologist. The usual sonographic criteria for a positive diagnosis were the visualization of a noncompressible tubular structure greater than 7 mm in diameter, located in the right lower quadrant, possibly associated with intraperitoneal fluid, the presence of fecolith and/or hyperechoic periappendicular fatty tissue. Complications such as a periappendiceal mass or abscess were noted. [10].

The senior pediatric surgeon had to validate the surgical diagnosis before study inclusion.

Patients included in this study were randomized in two groups: first, SILA group which were managed by one-port laparoscopy and second LA procedure with conventional laparoscopy (CLA) using three trocars, without choosing according to the appendicitis type.

A simple randomization was conducted using a random number table and each patient was then assigned to either SILA procedure or CLA. The randomization was done after the diagnosis (clinical, biological and ultrasound) and just before performing the surgical procedure; therefore neither the patient and his parents nor the nurses knew to which group the child was assigned.

All patients were under general anesthesia and received a rectus sheath block (RSB) which consisted in injecting a regional anesthetic (Naropeine 2%–0.3 mL/kg on each side of the umbilicus) to anesthetize the somatic nerves supplying the umbilical area. It was administered by the surgeon right before the incision. No curare was administered.

In the CLA group, a local anesthetic infiltration was realized for the 2 other trocar incisions in addition to the RSB.

All surgeries were performed by a single attending surgeon with assistance from either a pediatric fellow or senior surgical resident.

Commercialized ports such as Triport, SILS port are not really fitted for pediatric surgery. We used the SILA technique inspired by the Lee et al. description [11]. Standard 5-mm laparoscopic equipment such as 30-degree angle telescope (Storz, Deustchland) and straight rigid instrument, identical to those used in conventional laparoscopy (including grasper (Covidien, CN, USA); scissors (Storz, Deustchland), and electrocautery hook (Storz, Deustchland)) was used to perform our SILA. Each patient was placed in the supine position under general anesthesia. Using the open incision method, a vertical incision through the center umbilicus measuring 2–2.5 cm was made. An extra small wound retractor (Alexis®, Applied Medical, USA) was then introduced through the umbilicus. The homemade glove port with three 5 mm trocars was then fitted over the Alexis® (Applied) (Fig. 1). The pneumoperitoneum was established with an intraabdominal pressure adapted to the child's age; carbon dioxide gas leaked through one of the three trocars. The laparoscope was introduced through one trocar, and two graspers in the two other trocars for the peritoneal cavity examination. Once the appendix was identified and isolated, the mesoappendix was dissected and cauterized using monopolar hook. The appendiceal base was ligatured with two Vicryl® Endo-loop (Covidien, CN, USA) separated by 5 mm, above one another. The appendix was retrieved through the umbilical port site without EndoBag® (Covidien, Mansfield, San Diego, CA) through the wound retractor and put in the remaining unused and free fourth digit glove. The abdominal cavity was washed.

If there was any difficulty, SILA was simply converted: the glove port was removed and a 12 mm trocar was put through the umbilical incision. Additional ports were placed according to CLA. After removing

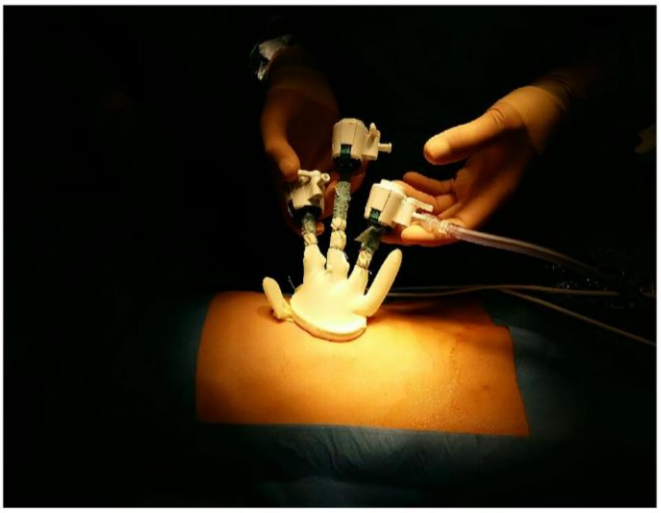

Figure 1. The homemade glove port with three 5mm trocars.

the glove port, the umbilical fascia was closed with 3-0 Vicryl® suture (Covidien, CN, USA). The subcutaneous layer was sutured with 4-0 Monocryl® suture (Covidien, CN, USA). The umbilical skin was sutured by a continuous stitch of Vicryl® rapid 4-0 (Covidien, CN, USA). An umbilical dressing was applied using a piece of gauze packed into the umbilicus covered with an occlusive dressing.

CLA was performed using a 3-trocars technique with a 12-mm infraumbilical trocar (Applied Medical, USA) placed by the Hasson open technique, and two additional 5-mm trocars (Applied Medical, USA) placed in the suprapubic area and the abdominal left lower quadrant. The remaining details of the appendectomy procedure were the same as SILA. An EndoBag® (Covidien, Mansfield, San Diego, CA) was used if we couldn't pull through the appendix through the 12 mm trocar.

Postoperatively, similar bandage was used for all of patients during the hospitalization with three adhesive dressings according to the three trocars sites, in SILA and CLA group. The postoperative comparison was also conducted as a blinded-study.

Pain in recovery room was evaluated by the Face, Legs, Activity, Cry, Consolability scale (FLACC) [12] and was managed by morphine titration according to this scale. The exit of the recovery room was authorized if patient had an ALDRETE scale [13] at 10.

Postoperative follow-up and management were identical in both groups. Oral administration of analgesics was started as soon as possible and late postoperative analgesic management associated paracetamol 15 mg/kg every 6 h systematically and Nalbuphine 0.2 mg/kg every 4 h via IV when the FLACC [12] was above 4/10. The IV perfusion was stopped when the patient was able to drink.

Hospital discharge was authorized as soon as the patient was pain free and had resumed feeding. All patients were followed 3 months after discharge for clinical evaluation.

The primary outcome measure was the operative time. The former collected data were described by means and standard deviations for quantitative variables, and numbers and percentages for qualitative variables. Intergroup comparison was performed with a Student t-test for quantitative data or with a Mann–Whitney nonparametric test for temporal data. Finally qualitative data were analyzed by a Pearson's chi-squared test. Epi Info™ 7.2 software was used for all analysis. The significance threshold was set at 0.05.

2. Results

40 patients were prospectively included in SILA group and 40 patients in CLA group. All epidemiological data were registered in table 1. All anatomopathological results for each group of the appendix were positive.

Table 1
Epidemiological data.

	SILA	LA	p value
No. of cases	40	40	
Mean age ± SEM, y (range)	11.6±2.2	10.6±2.5	NS
Male, n	23	18	NS
Female, n	17	22	NS
Median weight, kg (range)	38±13	39±10	NS
Appendix type			
Paracecal, n	24	28	NS
Retrocecal, n	16	12	NS
Peritonitis			
None, n	31	28	NS
Localized, n	5	6	NS
Generalized, n	4	6	NS
Abscess			
Yes	3	2	NS
No	37	38	NS
Intraoperative complications	0	0	NS
Conversion to open surgery	0	0	NS
Mean operative time (min)	33±9	41±12	0.049
Mean hospital length of stay (day)	2.6±2.6	4.1±3.6	0.016
Recovery room			
Mean duration (min)	38±19	54±17	0.02
Pain score: entrance	2.3±2.4	4.6±3.0	0.05
Pain score: exit	0.2±0.5	1.1±1.6	0.04
Morphine consumption (mg/kg)	0.06±0.07	0.10±0.06	0.05
Postoperative complications	0	1	0.53

The mean operative time for SILA was significantly lower than CLA procedure ($p=0.049$; 33±9 min versus 41±12 min). There were no postoperative complications in SILA group. We observed one postoperative intraabdominal abscess treated by intravenous antibiotherapy in CLA group without difference between each group ($p=0.53$). There were no conversion in SILA group to CLA and no open procedure for CLA and SILA group.

Peritonitis associated with appendicitis impacted significantly the operative duration in each group. If peritonitis was associated with appendicitis, the operative duration was not significantly different between each group ($p=0.79$; SILA = 39±15, CLA = 36±12) but if there was no peritonitis, this time was significantly lower in SILA group ($p=0.026$; 42±11 *vs* 32±9).

The duration in recovery room after surgery was 38±19 min for SILA and 54±17 min for CLA with significant difference between each group ($p=0.02$).

The pain score FLACC when entering the recovery room was higher in CLA group (4.6±3.0 vs 2.3±2.4; $p=0.05$) and to exit also (1.1±1.6 vs 0.2±0.5; $p=0.04$). There were no significant differences for the ALDRETE score between each group for entrance to (SILA: 9±0.9, CLA: 8.6±1.2; $p=0.34$) and for exit from (SILA: 10, CLA: 9.8±0.3; $p=0.14$) the recovery room.

The morphine consumption was significantly lower for SILA group according to patient weight (0.06±0.07 mg/kg vs 0.10±0.06 mg/kg; $p=0.05$).

If we compare SILA with CLA, we observed that SILA is less painful significantly than CLA for the first postoperative 6 h ($p=0.03$). After, even if SILA appears less painful, difference is not significant.

If we compare SILA and CLA for simple appendicitis, we observe that pain after SILA procedure is significantly less important than CLA for the first 9 postoperative h ($p=0.01$), without difference after 9 h. This observation is not the same for appendicular peritonitis; there is no difference in pain between each group ($p=0.38$).

The hospital length of stay was significantly higher in CLA than SILA group ($p=0.0156$) with 2.6±2.6 days for SILA and 4.1±2.6 days for CLA group. There is a significant impact of the appendicitis type on the hospital length of stay. Without peritonitis, the hospital length of stay was significantly decreased ($p=0.0006$) for SILA group (1.8±1) than in CLA group (3.5±2). In case of associating peritonitis, there was no difference between each group ($p=0.4$).

3. Discussion

The operative duration for SILA is significantly lower than CLA (33min versus 41, $p=0.049$). This result brings to light the feasibility of this procedure in emergency context as in routine without repercussion on the time of surgical room activity. Time for preparation of the glove port had no impact on the operative time because it was prepared during the anesthesia induction time.

The appendicitis type had influence on the operative duration and is supportive of SILA technique. If peritonitis is associated with appendicitis, SILA and CLA are efficient but if we observe simple appendicitis, SILA seems more performant according to the operative duration. SILA could be applied whatever form of appendicitis.

Our observation is different from the literature; a retrospective review comparing SILA and traditional multiport laparoscopic appendectomy [14] showed no statistically significant difference between each group according to operative times (43.63 *vs*. 40.95 min; $p = 0.29$). Esposito et al. [15] suggest, in their retrospective study, that SILA is a valid and safe procedure for uncomplicated cases but multiport laparoscopic appendectomy significantly reduces the operative time compared to SILA. For us, SILA is more performant according to operative time.

This technique had no more complications than CLA, which highlights the safety of SILA procedure. We have no perioperative complication in each group and one complication (Clavien 2 [16]) in LA group on postoperative time. Furthermore, no risk was brought for SILA procedure because the Alexis® was put with regards by an umbilical open procedure. If problems during surgery were encountered, we could remove this in a few seconds and apply a 12 mm trocar to switch to CLA. Finally, less risks were observed for us with SILA in trocar management because none was put throughout the abdominal wall directly. All of the three trocars were out of the abdominal cavity. When the optics are in position inside the umbilical trocar in CLA procedure, the operator is then putting the two other operative trocars through which instruments will be introduced. This time is also a source of complications. The introduction of these trocars has to be made under view control to reduce the risk of complications. Reported complications in the literature in touch with the introduction of operative trocars are [17,18]: vascular contusions (epigastric pedicle – estimated at 3/1000 [19] – parietal vessels, and external iliac vessels); digestive contusions (small intestine bowel, colon, stomach: 1.5/1000 [19]); bladder contusion and contusion of femoral nerve. In a U.S. Food and Drug Administration report, received from January 1, 1997, through June 30, 2002, 1399 accidents of trocars were observed; 31 (2.2%) were fatal [20]. SILA procedure allows not to take these risks of hurts.

We also think that this procedure could decrease the risk of bowel obstruction described after opening abdominal wall. A current meta-analysis [21] shows that CLA was associated with a significant reduction in the incidence of postoperative bowel obstruction in the general population and reduced significantly the incidence of postoperative bowel obstruction in pediatric patients and patients with perforated appendicitis. Furthermore, CLA was associated with a significantly reduced incidence of long-term bowel obstruction and bowel obstruction requiring surgery. This observation seems to bring to light that no open surgery and furthermore only one incision for laparoscopy could decrease more the risk of postoperative bowel obstruction. But more studies are necessary to prove this point.

The hospital length of stay was significantly higher in CLA than SILA group and impacted significantly the economic way in our unit.

Studies show that compared to open procedure, CLA has significant advantages with respect to length of hospital stay, rate of routine discharge, and postoperative in-hospital morbidity [22,23]. They bring to light the importance of appendicitis type which influences significantly the length of stay in each group, furthermore in CLA group.

Without operative trocar in SILA, no abdominal wall trauma through parietal muscle was done and it probably reduced postoperative pain and improved recovery time after surgery.

This procedure could be applied in outpatient surgery with a better control of postoperative pain for simple appendicitis without antibiotic treatment. We are currently continuing some studies in our center to improve the anesthetic way and analgesic management.

The cost of the homemade "one-glove" had no impact according to the reduction of hospital length of stay and reduction of analgesia consumption. The average cost is $25. Furthermore, during SILA procedure, the appendix was retrieved via the umbilical incision and put inside the fourth unused digit of the "one-glove" without using EndoBag® (Covidien, Mansfield, San Diego, CA). The cost of this one is $13. This homemade one-port appears extremely cheaper than the other commercial devices [11].

We grant honestly that SILA is associated with several ergonomic challenges compared with standard multiport laparoscopy owing to the handling of straight instruments in parallel with the camera. The single incision access decreases the range of movement for the surgeon and assistant; this has been associated with increased levels of surgeon fatigue and frustration [24].

The increased technical challenge owing to the lower mobility of instruments, collision as well as lower triangulation [25,26] does not affect the operative time in our study. Other studies criticized SILA procedure for the bad impact on surgery duration. Golebiewski report as our work a shorter operative time for SILA procedure [27]. We used a 30-degree angle telescope for a better vision. Telescope is on the same axe with operative grasp. 30-degree angle telescope improves the triangulation for a better and safe procedure. Furthermore, a longer grasp size improves the feasibility of the procedure for better triangulation and no hands conflict between the two operative grasps and with the hand holding the camera.

SILA procedure is also less painful. Only one incision throughout the umbilicus (which presents in most of cases a residual umbilical hernia) with a locoregional anesthesia with a rectus sheath block. By reducing trauma to the abdominal wall, SILA might potentially offer better outcomes than CLA [5]. Pain score recorded from the end of surgery procedure to the end of the hospitalization is significantly higher in the CLA group compared to SILA group. This result impacts significantly the recovery room length of stay and the hospitalization length of stay also. The use of one way with a rectus sheath block could explain this observation.

Most of the current techniques use at least three trocars [28]. For this reason, one critique of the laparoscopic approach commonly mentioned is that the combined length of the 3 incisions equals the length of an open appendectomy incision. Since then, an effort has been made to reduce the length of incisions and the number of abdominal ports needed to two or even one [5]. The incision made in the SILA group is inside the umbilicus which is a natural scar. Using this one and arriving in the abdominal cavity through a natural wall dehiscence had no cosmetic impact. This surgery appears to be scarless. This observation imposes the exploration of the bowel for Meckel diverticulum ablation.

4. Conclusions

SILA procedure for appendectomy appears to be safe and efficient for appendicitis management in children. This technique could be applied in routine as in emergency tome. We show a positive economic impact with reduction of recovery room and hospitalization length of stay. It reduces pain and seems to be a scarless surgery, which are major outcomes for patients nowadays. This technique should be more studied and practiced in the future.

Conflict of interest

All authors declare no conflicts of interest or financial ties to disclose.

Aurélien BINET, François LENGELLE, Karim BRAÏK, Marc LAFFON, Hubert LARDY and Sarah AMAR have nothing to disclose and declare no conflicts of interest or financial ties to disclose.

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CHAPITRE III

ÉTUDE PROSPECTIVE COMPARATIVE APPENDICITES SIMPLES

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Single-incision Laparoscopic Appendectomy versus Conventional Laparoscopic Appendectomy for simple appendicitis in children: what real benefits?

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Single-Incision Laparoscopic Appendectomy versus Conventional Laparoscopic Appendectomy for simple appendicitis in children: what real benefits?

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Abstract

Background: Single Incision Laparoscopic (SIL) surgeries tend to democratize in pediatric surgery as it appears safe, increases patient satisfaction and improves recovery. In a previous report, we studied SIL Appendectomy (SILA – SIL intracorporeal appendectomy) versus Conventional Appendectomy (CLA – conventional laparoscopy using three trocars) in all types of appendicitis. We focused here on simple appendicitis to enhance the control of postoperative pain and reduce our length of stay.

Methods: We prospectively included the patients in our pediatric university hospital center since January 2018 until January 2020. They were randomized into two groups of at least 70 patients: SILA and CLA. The primary outcome measure was the mean length of stay (LOS). Anesthetic management required a rectus sheath block for every patient and local infiltration for other trocars in the CLA group. Postoperative analgesic management consisted in only oral analgesics. All patients received antibiotics only peri-operatively.

Results: The mean operative time for SILA tended to be lower than CLA (33.1 ± 12.6 min versus 37.7 ± 14.3 min; p = 0.06). Mean duration in the recovery room was significantly lower for SILA (36.5 ± 24.5 min versus 47.3 ± 22.1 min, p = 0.01) and pain scores at entrance were also lower (1.6 ± 2.3 versus 2.6 ± 3.1, p = 0.05). Mean pain score after surgery was similar in both groups (p = 0.30). The hospital LOS was similar in both groups (respectively 30.8 ± 11.1 hours versus 34.7 ± 14.0 hours in SILA and CLA, p = 0.08). Drinking was reintroduced around 5 hours postoperatively and feeding around 10 hours in both groups without significant differences (p = 0.72 and p = 0.23).

Conclusions: Our results show a non-inferiority of SILA versus CLA and above all show that the establishment of standardized protocols can lead to earlier feeding and decreased LOS.

Keywords: Children. Appendectomy. Single-incision. Laparoscopy. Pain

Introduction

Appendectomy for acute appendicitis is one of the most common surgical procedures performed in pediatric surgery [1]. For over 30 years, since Semm first described it in 1983, laparoscopic appendectomy has been the gold standard in managing appendicitis because compared to open procedure, patients felt less pain, faster recovery, less wound infections and an improved cosmesis [2, 3].

With the continuous progress of minimal invasive surgery, and in order to enhance these improvements, Single Incision Laparoscopic (SIL) techniques were developed and keep gaining popularity since 2000 [4]. Thus SIL surgeries tend to democratize in pediatric surgery as it is safe, increases patient satisfaction and improves recovery [5] but various studies show conflicting results regarding clinical outcomes such as operative times, length of stay and cosmetics.

In our previous report, we studied the feasibility of SIL Appendectomy (SILA – SIL intracorporeal appendectomy) versus Conventional Laparoscopic Appendectomy (CLA – conventional laparoscopy using three trocars) for all types of acute appendicitis diagnosed in children [6]. We showed that SILA is efficient and safe whether used in a routine or emergency context. SILA had a decreased operative time, decreased duration in recovery room and morphine consumption, was less painful and had a shorter length of stay especially in uncomplicated acute appendicitis. Indeed, if peritonitis was associated, no significant differences were found between these two approaches.

Beside surgical techniques improvements, our healthcare system is constantly evolving and hospital management tends to reduce unit capacity in order to decrease costs. Improving efficiency without compromising safety and quality of care given is the new challenge for surgical teams. This leads us to adapt our practices in order to tend to same day discharge protocols under the best circumstances [7, 8].

Therefore, we focused on simple appendicitis to enhance the control of postoperative pain and reduce our length of stay in order to initiate outpatient surgery for simple

appendicitis. We thus improved our standardized protocols on anesthetic and analgesic managements.

The aim of our current study was to prospectively compare the post-operative outcomes of SILA and CLA for uncomplicated acute appendicitis at our institution by analyzing especially length of stay, pain management and complications.

Methods

Sample size

Sample size estimation was based on our previous results of length of stay (LOS) for uncomplicated appendicitis. We used a power of 0.80 and an alpha of 0.05, sample size was estimated at 138 patients. Children were then randomized into two groups based on the on-call surgeon's diagnosis and choice: SILA group using a homemade gloveport [6] and CLA group conventional three-port laparoscopy. Each group included at least 70 patients. Six trained surgeons performed the appendectomies: three only realized SILA and the others only CLA.

Data acquisition

Between January 2018 and January 2020, we prospectively included in our university institution after approval from our local ethical committee, patients under the age of 18 with acute appendicitis which appeared to be simple. Inclusion criteria were based on clinical (abdominal pain, essentially localized in the right lower quadrant, with or without fever, possibly associated with tenderness), biological (leukocytosis above 10 G/L) and ultrasounds findings (tubular structure in the right lower quadrant, noncompressible, greater than 7 mm, infiltration of peri-appendicular fatty tissue, with or without intraperitoneal fluid but without any complication such as mass, abscess or perforation) [1, 9].

We recorded the following data : age, sex, weight, duration and localization of the pain, biological markers (leukocytes, C-reactive-protein), ultrasound findings (appendix' size, fatty infiltration, intraperitoneal effusion), operative time and peri-operative complications, pain score in recovery room and the use of analgesic, LOS in the recovery room, post-operative pain score, drink and food intake, first mobilization, histological analysis, post-operative LOS, pain score at exit and post-operative complications.

Patients with complicated appendicitis (clinical sepsis or septic shock, signs of perforation on ultrasound or abscess) at diagnosis or after peri-operative findings (gangrenous appendix, perforation, peritonitis) were excluded from the analysis.

Surgical technique

We used the same surgical technique described in our previous article [6] using a homemade gloveport for SILA and conventional three port technique for CLA with only 5mm instruments. 6 attending surgeons performed the procedures, 3 of them did all the SILA from the beginning of our study. Surgeons were assisted by a surgical resident or a medical student.

Pain management

We improved our protocols since our first study. A rectus sheath block was used in both groups to control perioperative pain [6, 10]. It was a bilateral pre-incision ultrasound-guided rectus sheath block performed by the anesthesiologist, using ropivacaïn 2mg/ml solution. In addition for CLA group, peri-operative pain was also managed by local infiltration of the two other trocars at the end of the procedure. In the recovery room pain was evaluated with the Face, Legs, Activity, Cry, Consolability scale (FLACC) [11]. Morphine titration was used in case of pain according to the scale (first dose of 0.1 mg/kg). Exit of recovery room was possible when pain was controlled and children had a modified ALDRETE score at 12 [12].

Duration of time spent in the recovery room was also recorded to evaluate how long it took to control immediate postoperative pain. It was define by the time right after surgery to the entrance in the surgical unit.

Post-operative pain in the surgical unit was evaluated by the EVENDOL score. It was then managed only with oral analgesics: paracetamol and ibuprofen. Paracetamol at 15 mg/kg was administered only when EVENDOL score was above 4/15 and not every 6h hours as we first started. Ibuprofen was used after consulting our pharmacist on possible risks, indeed acute simple appendicitis was confirmed intra-operatively and a flash of antibiotics was administered during the procedure. If fever appeared post-operatively, no NSAID was given anymore. If pain was not controlled by oral analgesics, Nalbuphine was punctually given at 0.2 mg/kg.

Oral intakes and mobilization

Patients were authorized drinking upon returning to the surgical unit if they wanted to. Light food intake was allowed from the 4th post-operative hour and full intake at the next meal if light food was tolerated without any nausea or vomiting.

First mobilization was done after 6 hours if children were able to (pain controlled and no nausea or vomiting or dizziness).

Discharge criteria

Patients could be discharged when pain was controlled by oral analgesics (i.e EVENDOL score lower than 4/15), if they resumed drinking and feeding and when mobilization was completed and pain free, all without any fever.

Complications and follow-up

Early complications were recorded within 15 days after surgery. Rehospitalizations, intra-abdominal collection or abscesses, abdominal inflammation, fever, vomiting, parietal abscesses, redo surgery were searched for.

Long-term follow-up varied from 9 months to 2 and a half years after surgery.

Histological analysis

Every appendix removed was sent to histological analysis after surgery to confirm the diagnosis.

Outcomes / parameters investigated

The primary outcome measure was the length of stay (LOS) which was defined from the end of the surgery to the discharge of the patient. Distinction was made between “possible discharge”: time the patient could have been discharge from the hospital after resumed

drinking, feeding and mobilization without any postoperative complication (uncontrolled pain, fever, nausea/vomiting); and “actual discharge”: time the patient left the hospital.

The number of patient to include was evaluated based on our prior results regarding to our LOS. Indeed, LOS for simple appendicitis in SILA group was 1.8 ± 1 days versus CLA 3.5 ± 2 days.

Secondary outcomes were operative time, pain scores, time spent in the recovery room, analgesic intake and feeding, mobilization, complications.

Statistics

GraphPad Prism 8.0.2 software was used for all analyzes. The former collected data were described by means and standard deviations for quantitative variables, and numbers and percentages for qualitative variables. Intergroup comparison was performed with a Student t-test for quantitative data or with a Mann–Whitney nonparametric test for temporal data. Finally qualitative data were analyzed by a Pearson's chi-squared test or a Fisher’s exact test. The significance threshold was set at 0.05.

Results

Demographics / epidemiological data

Over 24 months, nearly 150 patients were prospectively included in our study (77 for SILA group and 71 for CLA group). Patients were included according to the Intention to treat concept. Baseline characteristics are presented in **Table 1**.

Diagnosis

Pain duration, presence of tenderness, fever, biological and ultrasound data collected showed no difference between SILA and CLA (**Table 1**).

Intra and peri- operative data

The mean operative time tended to be reduced for SILA versus CLA (33.1 ± 12.6 min versus 37.7 ± 14.3 min respectively; p = 0.06) (**Table 2**).

Duration in the recovery room was significantly shorter in SILA group (36.5 ± 24.5 min versus 47.3 ± 22.1 min; p = 0.01) as well as the pain score FLACC at entrance (SILA = 1.6 ± 2.3, CLA = 2.6 ± 3.1; p = 0.05). Morphine consumption was similar in both groups.

There was one conversion in SILA group to CLA (ergonomic issue of retrocecal fixed appendix) and no conversion in both groups to open surgery. No additional trocars were needed. We did not observe any intra-operative complication (**Table 2**).

Table 1: Epidemiological data

	SILA	CLA	p value
Male, n (%) Female, n (%)	48 (62.3%) 29 (37.7%)	41 (57.8%) 30 (42.2%)	0.61
Mean Age (range) years	10,7 ± 2.7 (3.2-15.2)	11,5 ± 2.4 (4.9-15.4)	0.06
Mean weight (range) kg	37.4 ± 12.8 (16-83.8)	42.4 ± 14.5 (16.7-74)	0.03
Mean Pain duration (range) hours	40.4 ± 48.2 (2-268)	38.6 ± 40.7 (3-240)	0.81
Tenderness, n (%)	12/77 (15.6%)	15/71 (21.1%)	0.40
Mean Temperature at diagnosis (°C)	37.0 ± 0.75 (34.8-38.7)	37.1 ± 0.66 (36-38.8)	0.78
Biological criteria: Mean (range) - Leukocytes (range) G/L - CRP (range) mg/l	 13.7 ± 4.4 (4.4-26.1) 23.2 ± 24.3 (0.3-101)	 13.4 ± 5.1 (5.4-31.8) 19.9 ± 21.7 (0.3-91.3)	NS
Ultrasound : Mean (range) - Appendix size (mm) - Caused probe pain (%) - Fatty infiltration (%) - Peritoneal effusion (%)	 8.9 ± 2 (5.7-14) 49.3% 81.1% 14.9%	 9 ± 2.2 (6-15) 51.6% 74.6 % 20.6%	NS

SILA: Single-incision laparoscopic appendectomy – CLA: Conventional laparoscopic appendectomy – NS not significant – Data are expressed as means with standard deviation and range into brackets or number and percentages

Table 2: Intra and peri- operative data

	SILA	CLA	p value
Mean operative time (min)	33.1 ± 12.6	37.7 ± 14.3	0.06
Recovery room :			
- **Mean duration (min)**	36.5 ± 24.5	47.3 ± 22.1	**0.01***
- **Pain score at entrance**	1.6 ± 2.3	2.6 ± 3.1	**0.05***
- Morphine consumption (mg/kg)	0.04 ± 0.07	0.04 ± 0.06	NS
Conversion to open surgery	0	0	NS
Intraoperative complication	1	0	NS

SILA: Single-incision laparoscopic appendectomy – CLA: Conventional laparoscopic appendectomy – NS not significant – Data are expressed as means with standard deviation or number of occurrence

Post-operative observations

Post-operative pain evaluation using EVENDOL pain score was similar both in SILA and in CLA groups (respectively 3.6 ± 2.5; 4.1 ± 2.4, p = 0.30). No difference was found between the two groups in the analgesics' needs furthermore in nalbuphine consumption when punctually given (p = 0.62).

Patients resumed drinking around 5 hours after surgery in both groups without any significant difference (SILA: 5.0 ± 3.0 hours versus CLA: 5.3 ± 4 hours, p = 0.72). Food recovery took place around 10 hours postoperatively (SILA: 10.8 ± 6; CLA: 9.5 ± 5.4, p = 0.23). Patients first got up about the 13^{th} postoperative hour (no difference between the two groups p = 0.74). Children could have been discharged from the hospital around the 17^{th} postoperative hour according to our discharge criteria in SILA group as in CLA group. Actual discharge tended to occur sooner for patients who underwent SILA versus CLA (respectively 30.8 ±11.1 versus 34.7 ± 14.0; p = 0.08).

EVENDOL pain score at discharge was similar and low in both groups.

Histological analysis came back as "subnormal" in 2 cases in the SILA groups and 2 cases the CLA group (p = 0.92). Results are presented in **Table 3**

Table 3: Post-operative observations

	SILA	CLA	p value
Post-operative pain (EVENDOL score)	3.6 ± 2.5	4.1 ± 2.4	0.30
Water intake (hours)	5.0 ± 3.0	5.3 ± 4	0.72
Food intake (hours)	10.8 ± 6	9.5 ± 5.4	0.23
1st mobilization (hours)	13.6 ± 6.2	13.3 ± 5.1	0.74
Possible discharge from hospital	18.5 ± 8.4	17.2 ± 5.8	0.34
Actual discharge from hospital	30.8 ±11.1	34.7 ± 14.0	0.08
Pain at discharge (EVENDOL)	0.5 ± 0.9	0.5 ± 0.8	0.87
Histological reports in favor of acute appendicitis	75/77 (97.4%)	69/71 (97.2%)	0.92

SILA: Single-incision laparoscopic appendectomy – CLA: Conventional laparoscopic appendectomy – Data are expressed as means with standard deviation or number of occurrences and percentages

Early complications within the 15th postoperative day occurred in nine patients of SILA (**Table 4**): 4 were hospitalized again and presented with intraabdominal collections (2) or abscesses (2), 1 was not discharge after surgery because he presented a fever 2 days after SILA leading to the diagnosis of an intraabdominal collection. All were treated by intravenous antibiotherapy. In CLA group, 4 patients were hospitalized again within 15 days for abdominal pain and fever, 2 presented ileitis, no intraabdominal collection was found. 7 had a longer length of stay because of vomiting. 1 came back for an umbilical wound infection. None of the patients in each group needed another surgery. No significant difference was found between the 2 groups in early complications (p = 0.63).

Long-term follow-up showed no more complications (from 9 months to 2.5 years).

Table 4: Post-operative complications within 15 days

	SILA	CLA	p value
Intra-abdominal collection	3 patients	0	
Intra-abdominal abscess	2 patients	0	
Ileitis/inflammation	1 patient	2 patients	
Vomiting	2 patients	5 patients	
Parietal abscess	0	1 patient	NS
Other (virosis / pain)	1 patient	1 / 2 patients	
Rehospitalizations	4 patients	4 patients	
Prolonged hospital stay	5 patients	7 patients	

NS not significant

Discussion

SILA has gained popularity since the first series of procedures using a gloveport and realized entirely intracorporeally was described in 2009 [4, 13]. However, although this new technique seems promising, several studies expressed doubts regarding its real benefits apart from improving cosmetic. Thus we aimed to compare SILA versus CLA focusing on uncomplicated appendicitis since they were no difference when peritonitis was associated in our previous report[6].

Operative duration

Our results showed that SILA tended to be shorter than CLA without significant difference (p = 0.06) but were against several results found in the literature [13–16]. It is often pointed out that SILA takes longer because of the technical difficulties and lack of experience using this technique [17]. In our experience, the same 3 senior surgeons performed all the SILA procedures, learning phase was over so there was no training bias that could impact mean operative time. It could be argued that since we first started the study, surgeons had time to perfect and master the technique, but mean operative times were similar between our 2 studies. Indeed, in our previous report, SILA was significantly faster than CLA in uncomplicated appendicitis (p = 0.026; 32 ± 9 min for SILA vs 42 ± 11 min for CLA) and mean operative time for SILA in the present study was 33.1 ± 12.6min. Ergonomic challenges did not impact operative time as we overcame triangulation issues by using longer graspers and a 30° angle telescope.

Intraoperative complications

Only one patient (1.3%) from the SILA group needed a conversion to CLA because of the appendix localization versus 2.4% of conversion reported by Salas de Armas [18] and 7% reported by Gates et al. [19]. No additional ports were added which was different from the literature where 4.3% [5] up to 16.7% of patients needed it [13]. Several explanations can be

given: first, our surgeons performing SILA procedures were experienced since our first study; second, additional ports are often needed when the appendicitis stage is more advanced intraoperatively than we might think before surgery whereas in the present study we focused on simple appendicitis.

Recovery room

Only few studies on SIL procedures focus on the immediate recovery and pain. Mean duration in the recovery room was significantly shorter for SILA than CLA group as well as the pain score. These findings are similar to our previous results, however we noticed that the pain score at the entrance to the recovery room was lower in the present study. Also, morphine consumption was not different between the two groups in the present study whereas in our previous study it was lower for SILA group. This may be explained by the improvement of our anesthetic protocol. Indeed, we used a rectus sheath block (RSB) for the umbilical incision which was not done on a regular basis in our previous study. Likewise, Hamill et al. in 2015 [20] found that RSB lowered pain scores after laparoscopic appendectomies in children in the first 3 hours after surgery without affecting opioid consumption. The two more scars in CLA could also explain the difference in pain score because local anesthetic is less effective than a profound block and the local infiltration was performed at the end of the procedure. Also, as suggested Esposito et al. [3], a longer laparoscopy can cause more pain due to the pneumoperitoneum duration and in our case, CLA was longer than SILA.

Postoperative pain and management

Pain scores were similar in both groups as it was found in Mayer et al. 2011 [21], whereas some studies reported increased pain level in SILA groups [16] and analgesic consumption [14] but neither used a RSB before surgery. We only used oral analgesics and pain was well-controlled according to the EVENDOL pain scores right after surgery (below 4/15) and before discharge (overall average pain score was less than 1 in both groups). As K.M. Gee et al. showed [22], post-operative pain control can be achieved using only non-opioid treatments versus L.A Benedict et al. [7] who used oxycodone. We also noticed that, despite the use of ibuprofen, which is often less recommended in bacterial infectious disease [23], no

more postoperative infection was recorded. Furthermore combination of ibuprofen and paracetamol is proven to be effective in acute pain such as post-operative pain [24].

Also, the use of only oral analgesics is one more step towards same day discharge as they can easily be used at home.

Oral intake and mobilization

Children started to drink after approximately 5 hours in both groups and feeding around 10 hours which was sooner than some studies [17]. Mobilization was similar in both groups around the 13th hour which seems to be late. This could be explained by the access to the operating room in our institution. Indeed, surgical emergencies often have to wait after scheduled surgeries and children are often operated late in the evening which leads to late mobilization the next morning.

LOS

Patients stayed less than 1.5 days after surgery, and SILA group tended to get out earlier than CLA. Our LOS was shorter than PCY Chang et al. [13] for uncomplicated appendicitis and was reduced prior to our previous study. This could be explained by the improvement of our analgesic and feeding protocols.

Complications

Complication rates were similar in both groups. 4 patients in SILA group were hospitalized again within 15 days after surgery for intra-abdominal collection or abscess. When looking for histological reports, these patients presented with suppurative or ulcerated appendix with very intense peritoneal reaction. No patients came back for wound infection in SILA group due to the use of the gloveport system which prevents from the contamination of the umbilical incision and the intracorporeal appendectomy, versus one patient in CLA group. One limitation is that patient could follow-up in another hospital in case of complications, yet

our facility is the only children's hospital in the region and parents often come back where their child was first treated.

Long-term follow-up (from 9 months after surgery up to almost 3 years) showed no complications, especially no bowel obstructions which were proven to be decreased by CLA [25] procedures and are possibly even more low after SILA. However longer post-operative follow-up studies are needed to confirm this observation.

Towards outpatient surgery

One of our objectives was to improve our postoperative management whatever the surgical technique used. Children could drink right after surgery and eat from the 4th postoperative hour according to our protocol. However, changing the mind set in our unit was challenging. Indeed, our results showed that patients resumed drinking only 5 hours after surgery and food intake after 10 hours, as for mobilization it was done after 13 hours, although authorized after 6 hours. We thus calculated when children could possibly have been discharged according to outpatient criteria as used in Cash et al. [26] and mean actual discharge was more than 12 hours later. This finding is partly explained by our management of acute simple appendicitis. Children are operated most of the time after scheduled surgeries (after 5 PM) and spend the night in our surgical unit which delays oral intake and mobilization. If we could operate them as ambulatory patients, the postoperative stay would probably be shorter. "Old habits" of our previous management could also explain these delays [27]. Indeed, while nurses and surgeons became more familiar with the protocol, oral intake, mobilization and hospital stays tended to shorten and we succeeded in decreasing our LOS since our previous study. Our next challenge would be to implement a same day discharge protocol for uncomplicated appendicitis where children would came back in the morning in our outpatient clinic and could be released the same day.

Cosmetic

We did not address cosmetic outcome of SILA nor CLA in the present study as scars should not be evaluated before at least 12 months after surgery. Thus, we are actually conducting another study to assess scar satisfaction of our patients in both groups.

In conclusion, traditional surgery is moving towards minimally invasive techniques for the past years. Single incision laparoscopic surgeries keep gaining popularity also in pediatric populations as it appears to be safe and efficient although its outcomes are controversial. Our study showed that SILA is non inferior to CLA in managing acute uncomplicated appendicitis in children. Also, standardized reinforced protocols reduced our length of stay and lead us one step closer to outpatient surgery. Further study should evaluate and validate protocols for same-day discharge appendectomy in children in order to reduce costs without compromising patient safety and satisfaction.

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CHAPITRE IV

ANALYSE COSMÉTIQUE

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Single-incision versus conventional laparoscopic appendectomy for children: is the cosmetic benefit real ?

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Single-incision versus conventional laparoscopic appendectomy for children: is the cosmetic benefit real?

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Abstract

Background: Single-Incision, versus Conventional, Laparoscopic Appendectomy in children is often advertised for its better cosmetic outcome (SILA versus CLA) but prospective data are lacking. Our aim was to compare cosmesis after these surgeries at long term.

Methods: Single-center prospective study including children (January 2018 until January 2020) and randomized into SILA and CLA groups. Scars were assessed on average 2 years after surgery using the Patient and Observer Scar Assessment Scale (POSAS). POSAS is a valid reliable scale for linear scars divided into two independent numeric subscales: Patient Scar Assessment Scale (PSAS) composed of 6 items (pain, itching, color, stiffness, thickness, and irregularity) rated from 1 (similar to normal skin) to 10 (worst scar imaginable); and the Observer Scar Assessment Scale composed of 5 items also rated from 1 to 10. Subjects were surveyed by telephone for PSAS. Three independent observers assessed photographs of the scars using the OSAS.

Results: 45 patients (58.4%) of SILA and 38 (53.5%) of CLA completed the PSAS (p=0.62). Mean time between surgery and scar assessment was 25.3±8.4 months for SILA and 22.2±6.7 months in CLA, without significant difference (p=0.07). No significant difference for each item of the PSAS nor in the total of 60 in both groups. Mean total score was 8.8±4.9 for SILA and 9.3±3.7 for CLA (p=0.61) proving a good satisfaction with their scars despite SILA's larger incision. Similar results were found using the OSAS scale.

Conclusions: SILA offers similar cosmesis than CLA, minus two scars. This result was confirmed by three independent observers.

Key words: Children. Appendectomy. Single-incision. Laparoscopy. Cosmesis

Introduction

Acute appendicitis is one of the most common diagnosis of abdominal emergency leading to a surgical procedure in pediatric surgery [1]. Laparoscopic appendectomy has been the gold standard for more than 30 years as it appeared less painful, increased patient satisfaction and decreased wound infection over open appendectomy [2,3].

Not only by improving patient's and parents' satisfaction but also to reduce postoperative morbidity, Single-Incision Laparoscopic Surgeries (SILS) have gained popularity since 2000 as potential scarless surgeries [4]. Although controversial outcomes in terms of operative times, pain scores and length of stay have been described without differences in terms of complications [2,5,6], almost all of the studies agree on the cosmetic advantage of SILS [7]. Indeed, cosmetic benefit is often pointed out as a major outcome of SILS but there are only a few prospective comparative studies assessing the real cosmetic perception after SIL Appendectomy (SILA) in children [8,9].

We previously prospectively compared the outcomes of SILA versus Conventional Laparoscopic Appendectomy (CLA) in children and reported SILA's safety and feasibility in pediatric surgery [10]. As scar evaluation should not take place in early follow-up but rather at long-term follow-up, we performed scar assessment after scar maturation to search for definitive significant difference between the two surgical techniques.

Thus, we aimed in this study to evaluate cosmesis outcome of SILA and CLA of our previous enrolled patients and to determine if one of the approach offers a better cosmetic perception.

Methods

Patients' characteristics

We conducted a prospective comparative study of the cosmetic outcome of SILA versus CLA in children after local ethical approval. Patients and their parents were asked to evaluate their scars at least at one year after surgery. As cosmetic assessment was not the primary outcome of the study, sample size was determined based on the previous primary outcome (length of stay) and not by expected differences in cosmetic outcome.

Surgical procedures

Surgical techniques of SILA and CLA were previously reported by our team [10]. For SILA, an umbilical vertical incision through the center measuring 20 to 25 mm was made to insert an extra small wound retractor (Alexis®, Applied Medical, USA). For CLA technique, the umbilical incision was around 10 to 15mm, and two other incisions were made for the introduction of 5mm trocars. Each facial umbilical incision was closed using a slowly absorbable suture size 3/0. Subcutaneous sutures were placed depending on the height of the layer using a resorbable suture. Skin was closed using a rapid 5/0 undyed braided absorbable suture (Vicryl Rapide™ Ethicon®) for the umbilicus and standard undyed monofilament absorbable suture for the other trocars in CLA (5/0 Monocryl™ Ethicon®).

Scar assessment

After literature search and based on clinical practices, we chose to use the Patient and Observer Scar Assessment Scale (POSAS). Indeed, POSAS has been proven to be a reliable, feasible, consistent, and valid scale to assess scars, initially for burns [11] and then validated for linear scars such as postsurgical scars [12]. An international survey also showed it was the predominantly used subjective score in daily clinical practice [13]. This choice was also made to highlight the importance of the patients' opinions of their scars as patients and healthcare

providers do not always agree on scar appearance [14] and the patients' own view of the scar can be very influential in determining their quality of life [12].

This patient-centered scale consists of two independent numeric subscales: the Patient Scar Assessment Scale (PSAS), which is completed by the patient, and the Observer Scar Assessment Scale (OSAS), which is filled out by the observer. The PSAS is based on 6 items (pain, itching, color, stiffness, thickness, and irregularity) scored on a numeric rating from 1 to 10, 1 being "normal skin" and 10 "worst scar imaginable". A total combined score is then established of 6 to 60. The OSAS measures vascularization, pigmentation, thickness, relief and pliability with the numeric rating from 1 to 10 and a combined score from 5 to 50 [11].

Subjects were surveyed by telephone using the French adaptation of PSAS (validated by Deslauriers et al. in 2009) approximately from 12 postoperative months after surgery with parents' and children's consent [15]. To ensure consistency, the same surgical resident interviewed all the patients. Children over 10 years old could answer to the PSAS questionnaire themselves, whereas parents of the patients under 10 years old completed the survey. For the OSAS, as it appeared difficult to reconvene patients one year or more after a minor surgery, photographs of the scars were analyzed by three independent pediatric surgeons (two attendings in pediatric plastic surgery and one resident in pediatric surgery) blinded to the surgical technique used. The OSAS was reliably used in several studies on photographs [16–18]. As the item "Pliability" has shown poor reliability when used on photographs like Fontana et al. reported, it was not included [18]. All other variables have shown reliability with photographs [16]. Thus, we used a "modified" Observer assessment scale which had a possible combined score of 4 to 40 [18].

Statistical analysis

GraphPad Prism 8.0.2 software was used for all analyzes. The former collected data were described by means and standard deviations for quantitative variables, and numbers and percentages for qualitative variables or by median and extremes for smaller samples. Intergroup comparison was performed with a Student t-test for quantitative data or with a Mann–Whitney nonparametric test. Finally qualitative data were analyzed by a Pearson's chi-squared test or a Fisher's exact test. The significance threshold was set at 0.05.

Results

All of the 148 patients enrolled in the previous study received a telephone call to complete the PSAS. Three attempts per patient were made to evaluate the maximum of subjects and improve response rates.

In the SILA group, 45 patients of the 77 first enrolled responded with a response rate of 58.4% whereas in the CLA group, 38 patients answered over 71 with a response rate of 53.5% without significant difference (p = 0.62). Mean age was 10.3 ± 2.7 years for SILA and 11.8 ± 2.4 years for CLA, with 64.4% male in SILA (29/45) and 50% in CLA (19/38) without significant difference.

Mean time between surgery and scar assessment was 25.3 ± 8.4 months for SILA patients and 22.2 ± 6.7 months in CLA group, without significant difference (p = 0.07).

There was no significant difference for each item of the PSAS nor in the total over 60 in both groups. The mean total score was 8.8 ± 4.9 for SILA and 9.3 ± 3.7 for CLA (p = 0.61) (**Table 1**) proving a good satisfaction with their scars whatever the technique used (**Fig. 1**).

However, a significant greater proportion of patients who underwent SILA had a PSAS total score under 10 (91.1%) whereas 73.7% of CLA patients presented with a total score under 10 over 60 (p = 0.04) (**Fig. 2**). We also look at each item to evaluate the proportion of patient declaring a score at 1, as normal skin. Color was the only item where we found a significant difference: 62.2% of SILA patient declared a score at 1 for color and only 26.3% found the color of their scar being like normal skin (p = 0,0018) (**Fig. 3**).

Three independent pediatric surgeons evaluated the photographs using the "modified" OSAS. Only 22 patients of the SILA group and 12 patients of CLA sent back photographs of their scars. As the sample sizes were small, median scores were compared using a Mann-Whitney test. Means were calculated from the three observers' scores for each item and the total Observer scar scale. We did not found significant difference in any item of the modified OSAS nor in the total over 40. Median total score was 6.2 (range from 4 to 12) in SILA group and 5.3 (range from 4 to 10) in CLA group (p= 0.94) (**Table 2**).

Tables

Table 1: PSAS scores detailed by item

PSAS	SILA	CLA	P Value
Pain	1.4 ± 1.2	1.6 ± 1.3	0.32
Itching	1.5 ± 1.1	1.4 ± 1.1	0.79
Color	1.7 ± 1.3	2.1 ± 0.9	0.09
Stiffness	1.5 ± 1.3	1.3 ± 0.7	0.47
Thickness	1.4 ± 1.3	1.3 ± 0.7	0.45
Irregularity	1.4 ± 1	1.6 ± 1.4	0.50
Total Patient Scar scale	8.8 ± 4.9	9.3 ± 3.7	0.61

SILA: Single-Incision Laparoscopic Appendectomy – CLA: Conventional Laparoscopic Appendectomy – Results expressed as mean ± standard deviation, p value Student t test

Table 2: OSAS scores detailed by item

OSAS	SILA	CLA	P Value
Vascularization	1 [1-2]	1 [1-3]	0.70
Pigmentation	1.8 [1-3.3]	1.5 [1-4.7]	0.53
Thickness	1.3 [1-4.3]	1.3 [1-2.7]	0.68
Relief	1.7 [1-4.3]	1.3 [1-2.5]	0.54
Total score	6.2 [4-12]	5.3 [4-10]	0.94

SILA: Single-Incision Laparoscopic Appendectomy – CLA: Conventional Laparoscopic Appendectomy – Results expressed as median and range between brackets, p value Mann-Whitney test

Figures

Fig. 1: Photographs taken two years after surgery: SILA on the left; CLA on the right

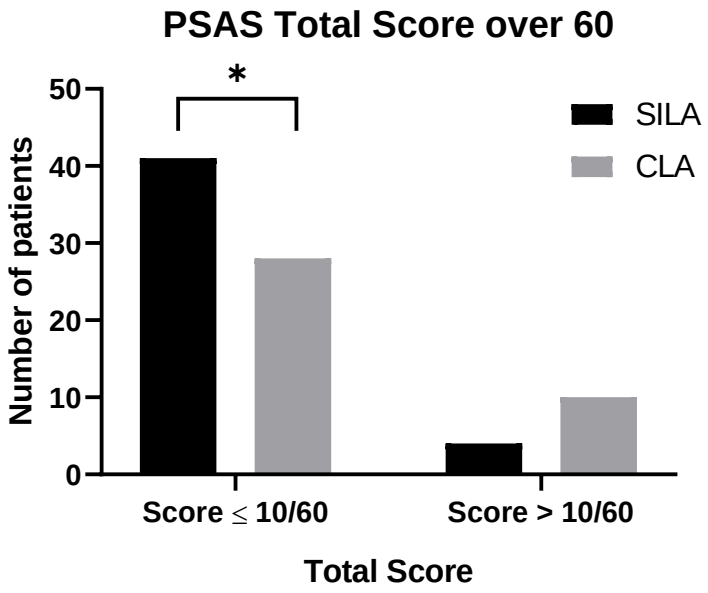

Fig. 2: Percentages of patients with a Total PSAS score under 10.

***: Significant difference, p = 0.04, Student t test**

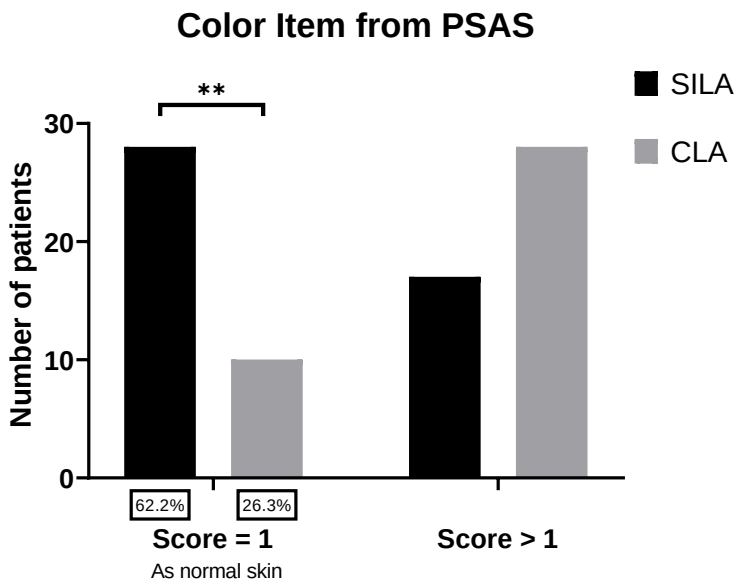

Fig. 3: Color Item from PSAS score under 1 meaning "as normal skin".

**** Significant difference p= 0.0018, Student t test**

Discussion

With the continuous progress of minimal invasive techniques and the wish for scarless surgeries, Single-Incision Laparoscopic Surgeries (SILS) gained popularity since the last two decades. SILS are safe and efficient including in pediatric populations and SILA is one of the most performed procedure. Despite controversial outcomes regarding operative times or length of stay [2,10,19], almost all studies agree on the cosmetic benefit of SILA with a lack of prospective data focusing on cosmesis in children.

The aim of this study was to assess scars of patients who underwent SILA and CLA after maturation and search for a difference. We did not find any aesthetic difference between SILA and CLA. The cosmesis appearance was therefore similar with a discreet scar, inside the umbilicus, almost invisible and similar to the "natural scar result" after birth. However, CLA patients have two additional visible scars.

148 patients were prospectively included in this study one year after surgery for scar assessment. Indeed, several studies reported cosmetic evaluation for SILS under 12 months after surgery [9,20,21]. Others compared the patients' scar evaluation at short (6 weeks) and long-term (25-26 months) [8,22] and found each time that the patients' impression changed between short and long term assessments as the scars evolved. Thus, we chose to wait for scars maturation to evaluate them as the definitive aspect is the one that matters the most. No difference was found between SILA and CLA in the present work at approximately 2 years after surgery which is consistent with some reports in children [8] and in adults at long-term (more than 12 months) [4]. Whereas reports about SILS scar assessments under 12 months after surgery often favours SILS in adults [20,21], it emphasizes the importance to wait to evaluate definitive scar appearance as the cosmetic benefit seems to vanish over time.

However, it has to be noted that our results do not undermine the great cosmetic outcome that SILA provides but simply show that patients are already highly satisfied with CLA using three trocars even though they present with two more scars. Indeed, during telephone interviews of CLA patients, many expressed that they did not even see the scars anymore or almost forgot they had three scars. This could be explained by the fact that in our center, the two other scars are often hidden in the underwear as we put a trocar low in the left iliac fossa

and the other one in the suprapubic region. Although, it may be nuanced by the fact that CLA patients do not know how SILA scar looks like and their expectations are correlated to the type of surgical technique used without knowing what it could have been with the other approach [21].

The patients impressions and the observers analyzes were consistent as both categories found a great overall outcome of the two surgical techniques. Although patients' feedbacks matter the most, it is important to see that surgeons' assessment matches the expected effect and the POSAS is a great two-sided tool to ensure this.

PSAS also evaluated symptoms such as pain and itching that influence the quality of life and showed a high correlation with patients' perception [16]. Despite the fact that SILA's scars are slightly larger, patients did not experienced pain or itching at long-term even though it is suggested by others [4]. The only significant difference we could found was when assessing which item was described strictly as normal skin (score equal 1): color was the only thing patients of CLA group found less like normal skin. This could be explained by the fact that CLA patients presented with three different scars with two (lower abdominal scars) often more visible than the umbilical one. This highlights the fact that, even if SILA and CLA patients present with similar overall satisfaction of their scars, similarity relies essentially on the umbilical scar and CLA patients have two more visible scars.

As mentioned before, SILA scars are slightly larger due to the use of a wound retractor in our approach. Even though we used the extra-small one, the minimum size of the Alexis® was 2 cm. It could be argued that, for younger children, a 2 cm incision in the umbilicus is still big and risks to leave a larger scar. So, in smaller patients we performed an S shaped incision which falls right within the edges of the umbilicus, therefore hidden. This technical artifice makes it possible to obtain a scar hidden inside the umbilicus by taking a fold of skin and contributes to the fact that SILA has a cosmetic result similar to CLA.

Response rate was more than 50% in both groups with a mean time between surgery and scar assessment of approximately two years which is a better response rate than the one obtained by Chandler et al. and at a longer term [9]. Gasior et al. also had a lower response rate than the present study with only 31.1% of single site (56/180) and 27.2% of 3-port (49/180) patients of the primary study [23] answering at a similar time after surgery (median

of 25 months)[8]. Thus, to the best of our knowledge, this is the first study to report on cosmetic comparison between SILA and CLA for children at long-term with a high response rate.

One could argue that the Observer scale was not design to be used on photographs. As we wanted to evaluate scars at long-term, and with the difficulty to convince and motivate healthy young patients at one year after a minor surgery to attend a clinical examination, we thus assessed them using the Observer scale of the POSAS on photographs. Some items like thickness and vascularization could seem to be difficult to assess on photographs but it has been done before like in Crowe et al. 1998 [24]. Moreover, several studies revealed scar ratings using photographs to be equivalent to in-person patient assessment in post-operative linear scars and removing the item “pliability” was also reported and validated several times [17,18,25].

Our report has several limitations. First, we did not assess scars at short-term and therefore could not realize a comparison of short- and long-term outcomes but our opinion is that short-term satisfaction does not influence the definitive satisfaction as scars are not mature yet. Second, as mentioned above, since it appeared difficult to reconvene patient long after a minor surgery, we did not realize a clinical scar assessment at long term. Also, we could not analyze a lot of photographs as not all of our patients agreed on providing them. However, it has to be noted that the PSAS and the OSAS were consistent.

Conclusion

Surgeons are always seeking new techniques to provide greater benefits to patients that is why single-incision laparoscopic surgeries were developed. An efficient surgery without any scar remains the fantasy of every patient and surgeon. Cosmetic superiority of SILS has been often advertised as a major benefit in several studies, and SILA seems to answer to the desire of “scarless surgery” for the management of acute appendicitis in children. We demonstrate here that the cosmetic result of the trans-umbilical approach of SILA is identical to CLA, leaving a hidden scar in the umbilicus with the advantage of no conspicuous scar. SILA seems to have its place in the management of acute appendicitis with results that are both functional and aesthetic. Our study also highlights the fact that adding trocars does not cause too much aesthetic prejudice at long-term and should be considered in case of difficulty during SILA.

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DISCUSSION

Depuis la technique chirurgicale princeps décrite par McBurney en 1894 [1], l'appendicectomie par voie ouverte a laissé place à la **laparoscopie conventionnelle** utilisant trois trocarts, considérée à l'heure actuelle comme le Gold Standard dans la prise en charge chirurgicale de l'appendicite chez l'enfant.

Devant une volonté perpétuelle d'amélioration technique et des bénéfices apportés aux patients, tout en diminuant toujours les complications, est apparue l'appendicectomie laparoscopique à **incision unique** dans les années 2000. Séduisante par son aspect cosmétique, passant par l'orifice naturel unique qu'est l'ombilic, son utilisation s'est popularisée depuis une dizaine d'années avec des résultats encore controversés à l'heure actuelle.

I - Analyse des résultats

Notre **étude préliminaire** a permis d'affirmer la **faisabilité** de SILA en contexte d'urgence. Nous avons retrouvé des temps opératoires significativement plus courts lors de l'utilisation de SILA d'environ 10 minutes, notamment en cas d'appendicite non compliquée, (contrairement à ce qui était retrouvé dans de nombreuses études [2–6].

En post-opératoire immédiat, les patients présentaient des douleurs moins importantes avec un temps passé en salle de réveil significativement moindre et une consommation de morphiniques abaissée. Les premières heures étaient également significativement moins douloureuses et les durées de séjours raccourcies. Ces constatations sont en partie imputables à l'absence des deux incisions supplémentaires nécessaires à la CLA. En effet, les deux incisions ajoutées lors de la CLA passent à travers les muscles contribuant ainsi aux douleurs malgré l'infiltration locale, allongeant donc le rétablissement avec la nécessité plus importante de prise d'antalgiques. Par ailleurs, la mise en place des deux trocarts supplémentaires, nécessitant par la suite fermeture, peut expliquer la différence de durée opératoire entre SILA et CLA.

Il est également intéressant de noter que dès l'étude préliminaire, les difficultés techniques souvent décrites comme associées à SILA dans les études [7,8] ne se sont pas

traduites par l'augmentation du temps opératoire pour SILA. Les adaptations techniques (instruments plus longs, optique à 30° avec trocart plus long) ont permis aux chirurgiens pédiatres, déjà expérimentés en laparoscopie conventionnelle, d'outrepasser les difficultés ergonomiques.

Nous n'avons retrouvé aucune complication péri-opératoire lors de la mise en place de cette nouvelle approche chirurgicale et en particulier aucune conversion n'a été nécessaire. SILA est donc **fiable** et **sans danger** surajouté par rapport à la CLA. Elle permet même de s'affranchir des risques liés à l'introduction de deux trocarts supplémentaires (plaies digestives, vasculaires, vésicales).

Notre **deuxième étude prospective,** centrée sur les appendicites non compliquées, nous a permis de **confirmer** nos résultats préliminaires. En effet, on retrouve un temps opératoire sensiblement plus court pour SILA avec une durée en salle de réveil significativement moindre associée à un score de douleur à l'entrée en salle de réveil plus faible que pour CLA. En revanche, la consommation de morphiniques n'était pas différente en post-opératoire immédiat, cela étant probablement dû au fait que notre première étude incluait tous types d'appendicites, simples et compliquées. Les suites opératoires étaient similaires pour les deux techniques sans douleur surajoutée pour les patients opérés par SILA. Les complications post-opératoires après SILA étaient similaires à celles rapportées pour CLA et aucune complication à long terme n'a été retrouvée dans les deux groupes (recul moyen de 2 ans).

Les résultats présentés ne diffèrent donc pas entre nos deux études successives, permettant de confirmer que SILA est une technique **sûre**, **efficace,** sans augmentation du temps opératoire malgré les ajustements techniques nécessaires et avec des **suites post-opératoires équivalentes** à la technique de référence qu'est la CLA.

Toutefois, ce travail nous a permis de modifier notre prise en charge péri-opératoire des appendicites simples. En effet, notre première étude nous a conduits à améliorer nos protocoles anesthésiques et postopératoires de prise en charge de la douleur et de réhabilitation.

Initialement, le bloc para-ombilical était réalisé par le chirurgien avant l'incision après champage stérile. Par la suite, les blocs para-ombilicaux ont été réalisés par les anesthésistes sous contrôle échographique la plupart du temps avant l'incision, améliorant ainsi la précision et l'efficacité de ce type d'analgésie. Par ailleurs, après la sortie de la salle de réveil, seulement des antalgiques per os de palier I étaient administrés avec un bon contrôle des douleurs.

La reprise hydrique et alimentaire était également plus précoce avec une bonne tolérance de même que la mobilisation permettant alors d'obtenir des durées de séjours plus courtes (passant de 43h à 30h pour SILA et de 84 à 35h en moyenne pour CLA pour les appendicites non compliquées) entre nos deux études prospectives.

Sur le plan **cosmétique**, avancé comme l'un des atouts majeurs de SILA dans de nombreuses études malgré le manque de données prospectives, notre **troisième étude prospective** a retrouvé des résultats similaires sur les cicatrices ombilicales des deux approches. Bien que l'incision trans-ombilicale de SILA soit plus grande qu'habituellement, parfois avancée comme un désavantage de la technique, elle reste néanmoins peu visible et en lieu et place d'une cicatrice embryonnaire naturelle. Par ailleurs, sa réalisation en « S » dans les replis ombilicaux pour les plus petits enfants réduit sa largeur. De fait, lors du questionnaire PSAS pour l'évaluation cosmétique, la moitié des patients décrivaient spontanément cette cicatrice comme invisible. De plus, l'analyse sur photographies, réalisée par trois observateurs distincts, a retrouvé des scores similaires entre les deux techniques et relativement proches de l'aspect de peau « normale ».

L'incision plus large (cutanée et aponévrotique) est également décriée pour son risque de hernie ombilicale à distance de l'opération, supposé comme augmenté pour certains auteurs [7]. Néanmoins, il n'a jamais été rapporté en tant que tel dans la littérature chez l'enfant et nous n'en n'avons pas constaté après les deux ans de suivi moyen.

Cette technique offre donc une **cicatrice unique** cachée dans l'ombilic, satisfaisant patients et évaluateurs, et l'avantage de deux cicatrices en moins dont l'absence est cosmétiquement un point positif.

II - Perspectives

A- Courbe d'apprentissage

Nous n'avons pas abordé au cours de ce travail la **courbe d'apprentissage** de SILA. En choisissant d'étudier les temps opératoires moyens comme reflétant cette courbe d'apprentissage, nous pouvons déjà observer que ceux-ci, dans nos deux études, étaient inférieurs à la CLA. La différence peut être imputée à l'absence de mise en place de deux trocarts supplémentaires ainsi qu'à l'absence de leur fermeture. Cela prouve néanmoins que, pour des chirurgiens seniors expérimentés en laparoscopie, la maîtrise de la technique à incision unique ne demande pas beaucoup d'interventions. En effet, les principales difficultés à surmonter sont la triangulation inversée, la vision plus limitée et l'absence de degré de liberté externe.

Actuellement, une étude est en cours afin d'établir précisément la courbe d'apprentissage de SILA. D'après les temps opératoires moyens des quarante premiers patients opérés selon SILA, pour chacun des chirurgiens seniors les effectuant et en les comparant à leurs temps opératoires moyens de CLA, on retrouve que seulement **8 patients** sont nécessaires pour descendre en-dessous de la durée moyenne de CLA. Les résultats détaillés feront l'objet d'une future publication.

B- Coût

Devant la mise en place de cette nouvelle approche chirurgicale de l'appendicite chez l'enfant s'est posée la question de son **coût**. En effet, plusieurs études internationales rapportent en critère secondaire d'évaluation des différences de coût entre les deux techniques, avec SILA décrite le plus souvent comme plus chère [4,9,10]. Les causes avancées sont essentiellement la durée opératoire plus longue retrouvée dans ces études, ou encore l'utilisation de ports commerciaux bien plus couteux que l'utilisation du gloveport.

Nous avons étudié le prix de revient de SILA en utilisant la technique du **gloveport** dans notre centre. Le coût global en termes de matériel consommable était de **60.14€** (28€ pour un écarteur d'Alexis® Applied Medical de petite taille, 0.94€ pour le gant chirurgical sans latex, 31.2€ pour les trocarts de 5mm). Le prix d'une **CLA** en termes de matériel consommable est lui de **52.68€** (26.4€ pour le trocart optique de 10mm, 15.6€ pour le kit de 2 trocarts de 5mm et 10.68€ pour le sac d'extraction endoscopique – non utilisé dans le gloveport puisque que l'appendice est extrait dans un doigt de gant). Ainsi la différence en termes de consommables était d'environ **7.5€** en faveur de CLA. Or, les durées d'occupation de salles opératoires et de salles de réveil étant diminuées, ce **surcoût** de matériel était alors **compensé** (coût moyen d'occupation de salle opératoire de 383€ pour SILA et 417€ pour CLA ; coût moyen d'occupation de salle de réveil 32€ versus 40€ respectivement). A noter que le port commercialisé par la société Applied Medical, le GelPoint mini®, revient à 237.6€ TTC.

Le **coût de l'hospitalisation** est lui tributaire de la nuitée et donc directement de l'heure de passage au bloc opératoire. Ce coût peut donc varier selon l'organisation interne de chaque service. En effet, dans notre service les urgences sont souvent opérées après le programme froid et donc en fin de journée, entrainant alors une nuit d'hospitalisation pour surveillance postopératoire devant la sortie tardive de salle de réveil.

A l'heure actuelle, il n'existe pas d'étude comparant exclusivement le coût des deux techniques dans la prise en charge de l'appendicite chez l'enfant et en particulier aucune étude Française. C'est pourquoi nous travaillons ce jour à une étude comparative financière des deux approches.

C- Vers une prise en charge en ambulatoire

La mise en place de cette nouvelle approche chirurgicale de l'appendicite aigue nous a permis de diminuer sensiblement les temps opératoires, significativement le temps de salle de réveil et d'accélérer la réhabilitation après chirurgie avec une diminution importante des durées d'hospitalisation pour appendicite simple entre nos deux études prospectives (pour rappel de 43h à 30h pour SILA et de 84h à 35h pour CLA).

Ces constatations nous font alors poser la question de la mise en place d'une prise en charge **ambulatoire** de l'appendicite aigue non compliquée chez l'enfant.

En effet, des temps de chirurgie courts, un flash peropératoire d'antibiotique seul, une diminution du temps en salle de réveil, des antalgiques per os et une réalimentation et mobilisation précoces sont autant de points se prêtant parfaitement à la chirurgie ambulatoire dans le cadre d'une réhabilitation accélérée après chirurgie.

Plusieurs études rapportent des protocoles standardisés afin de faciliter une sortie le jour même après appendicectomie laparoscopique chez l'enfant [11,12]. Plusieurs auteurs décrivent des taux de sortie le jour de l'intervention autour de 80% [11,13,14] avec pour certains une sortie s'effectuant directement depuis la salle de réveil [15]. Les durées de séjour postopératoires varient entre **2 et 8h** en moyenne. Les patients sortis le jour même ne présentaient pas plus de complications et des taux entre **7 et 8% de reconsultations** aux urgences étaient rapportés avec environ **2% de réhospitalisations** [11,13,15,16,17]. Les causes principales d'admission postopératoire en service d'hospitalisation classique étaient médicales (vomissements, douleurs), sociales (souhait des parents, domicile trop loin de l'hôpital) ou encore une opération trop tardive en soirée (82% restés une nuit en hospitalisation [18], deux tiers en cas d'intervention après 18h [11]). La plupart des études rapportent des taux de **satisfaction parentale** compris entre **80 et 87%** [13,19,20]. De plus, la prise en charge ambulatoire de l'appendicite non compliquée permet de diminuer significativement les coûts hospitaliers [16,20]. Ainsi, elle semble pouvoir s'intégrer dans les politiques de santé actuelles de diminution des coûts et de durées d'hospitalisation avec une amélioration d'efficacité sans nuire à la santé des patients.

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CONCLUSION

La technique de laparoscopie par incision trans-ombilicale unique a toute sa place dans l'arsenal thérapeutique pour la prise en charge chirurgicale de l'appendicite chez l'enfant, qu'elle soit simple ou compliquée.

En diminuant le temps opératoire, la durée en salle de réveil, la douleur et l'utilisation d'antalgiques post-opératoires ainsi que la durée de séjour, son évaluation au sein de notre institution nous a permis d'accélérer la réhabilitation des patients essentiellement en cas d'appendicite non compliquée.

L'initiation de cette nouvelle approche chirurgicale nous amène à réfléchir à la possibilité d'une prise en charge ambulatoire des appendicites simples de l'enfant, ce qui serait en parfait accord avec les politiques de santé actuelles : diminution des coûts sans perte d'efficacité et en toute sécurité pour le patient.

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90 pages – 7 tableaux – 3 figures —10 illustrations

Résumé :

L'appendicite aigue est la cause la plus fréquente d'hospitalisation pour syndrome douloureux abdominal aigu. Elle représente près de 30% des interventions de chirurgie digestive avec une incidence de 1.39/1000 habitants en France en 2009 tout âge confondu. Dans sa forme compliquée, perforation jusqu'à la péritonite généralisée, elle peut mettre en jeu le pronostic vital avec un taux de mortalité de 1.5 à 5% contre 0.1% dans les formes non compliquées.

Chez l'enfant, c'est l'une des urgences chirurgicales les plus courantes touchant 0.3% des enfants entre 0 et 15 ans. Son traitement reste avant tout chirurgical.

Dans un souci constant d'amélioration des bénéfices apportés aux patients, de nouvelles techniques prometteuses ont émergé au cours des cinquante dernières années détrônant possiblement la technique de référence par voie ouverte décrite dès 1894 par le chirurgien américain Charles McBurney.

La première partie retrace l'histoire de l'appendicectomie jusqu'à l'approche laparoscopique conventionnelle utilisant trois trocarts, et plus récemment l'utilisation de la voie trans-ombilicale unique.

Dans une deuxième partie, nous abordons la faisabilité de cette technique en chirurgie pédiatrique avec une étude préliminaire prospective monocentrique menée pour l'ensemble des appendicites diagnostiquées (simples ou compliquées).

Ensuite, la troisième partie compare, via une seconde étude prospective randomisée, les approches laparoscopiques conventionnelle et à incision trans-ombilicale unique, pour la prise en charge chirurgicale de l'appendicite simple uniquement.

Enfin, les résultats cosmétiques des deux techniques à long terme sont débattus via une enquête prospective.

Mots clés : Enfants. Appendicectomie. Laparoscopie. Incision trans-ombilicale unique. Cosmétique

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