S Afr J Surg. 2024;62:272-276. Online first
https://doi.org/10.36303/SAJS.00157

S Afr J Surg
ISSN 038-2361

HERNIA SURGERY

Role of multidetector computed tomography-based component separation index in the management of large ventral hernias

D Sharma,[1] V Upadhyay,[1] UC Garga,[2] R Lal[1]

[1] *Department of Surgery, Lady Hardinge Medical College & Associated Dr RML Hospital, India*
[2] *Department of Radiology, Lady Hardinge Medical College & Associated Dr RML Hospital, India*

Corresponding author, email: *drdeborshi@gmail.com*

Background: Predicting complete closure of large ventral hernias without component separation (CS) could have clinical value. The utility of multidetector computed tomography (MDCT)-based component separation index (CSI) was derived and evaluated for these hernias.
Methods: In 60 patients with a ventral hernia, a CSI was calculated based on their MDCT. In group I (first 30 patients), hernia repair was performed by an open approach and operative assessment determined the need for CS to effect complete closure. A CSI value above which defect closure needed CS was taken as the CSI reference point. In group II (second 30 patients), the hernia repair was done laparoscopically. Patients with a CSI at or below the reference point of group I underwent intraperitoneal onlay mesh (IPOM) after direct closure of the defect (IPOM-plus). The other patients had bilateral endoscopic component separation (ECS) before entry into the peritoneal cavity for an intended IPOM-plus.
Results: A CSI above 0.067 and 0.044 in open and laparoscopic approaches respectively required CS for complete defect closure. A CSI above 0.25 and 0.125 in open and laparoscopic approaches respectively, despite CS, predicted complete closure of defect was not possible.
Conclusion: CSI is a more comprehensive parameter for evaluation of ventral hernia than the conventional two-dimensional parameters and can predict the need of component separation prior to complete closure of the defect in both laparoscopic and open approach.
Keywords: component separation index, component separation, endoscopic component separation, multidetector computed tomography, laparoscopic ventral hernia repair, IPOM-plus.

Introduction

Ventral hernia accounts for 10% of all hernias.[1] Results of laparoscopic ventral hernia mesh repair (LVHR) are depicted to be better when they are associated with defect closure.[2,3]

Repair of large complex ventral hernias with loss of domain can be problematic as the hernia contents may not be replaced in the peritoneal cavity. This may lead to abdominal compartment syndrome or acute respiratory failure.[4] Ramirez et al. in 1990 popularised the component separation (CS) technique for repair of these complex ventral hernias[5] which is based on the concept of reestablishing a functional abdominal wall with an autologous tissue repair. CS today is described with both open and laparoscopic approach with and without mesh reinforcement.[6-9]

Component separation index (CSI) is calculated on a preoperative multidetector computed tomography (MDCT) which takes into account each patient's unique profile and can serve as an accurate biometric assessment of the abdominal wall. Standardising this index based on MDCT can help to decide preoperatively which patient needs CS for repair either by open or laparoscopic method.[10]

We conducted this study to assess the utility of MDCT-based CSI in deciding the necessity of CS during repair of large ventral hernias either by open or laparoscopic method.

Methods

All consecutive patients of age > 20 years and < 80 years with clinical diagnosis of ventral hernia were staged by the Petro classification.[11] Only first repairs in ASA grade I and II were included. Active infection, sinus or fistula at hernia site were excluded from the study. A written and informed consent was taken from all patients.

Preoperative calculation of CSI was done by a single radiologist on a preoperative MDCT performed in all patients from the dome of diaphragm to the inferior margin of the pubic symphysis with a 40 slice MDCT scanner. The CSI was calculated from the angle of diastasis (AD) of rectus musculature with the vertex based at the aorta on the preoperative MDCT. This was then placed as a comparator over 360°. Hence CSI = AD/360.

Open surgery was performed in the first 30 patients (group I) to calculate the CSI reference point, followed by the laparoscopic approach in the next 30 patients (group II).

In group I, ventral hernia repair surgery was performed using an open approach with a plan to close the defect and put a retro rectus mesh. If the defect couldn't be closed, a posterior CS was added to facilitate midline defect closure. Reference data was generated from this group and applied to group II.

In group II patients, the CSI was evaluated. A laparoscopic repair with or without endoscopic CS was based on the CSI reference point calculated for group I (Figure 1). All patients were operated on by a senior surgeon with experience in performing more than 250 laparoscopic ventral hernia repairs.

Technique

In group I, hernia repair was performed by open approach. Operative assessment for complete closure of defect was done. If complete closure of defect was not possible, CS was done using the transverses abdominis release technique. Normal microporous polypropylene mesh was placed in all cases in the preperitoneal space. The value of CSI based on the preoperative MDCT was noted in patients in whom primary complete closure of defect was not possible and CS was required.

In group II, ventral hernia repair was planned by laparoscopic approach. MDCT-based CSI value above which open primary complete closure of defect could not be done without CS in group I was taken up as CSI reference point for group II. Patients with CSI value below this CSI reference point were taken up directly for laparoscopic defect closure with IPOM (IPOM-plus). The remaining cases with CSI value above the reference point of group I had bilateral endoscopic sub-fascial CS before entry to the peritoneal cavity for IPOM-plus.

The basic principle of bilateral endoscopic sub-fascial CS or minimally invasive CS was to gain access to the lateral abdominal wall without creating a lipo-cutaneous flap. A 1.5 cm skin incision was made just below the tip of the 11th rib, the external oblique muscle was split, and a space was created between the external and internal oblique muscle using an indigenous gloved finger balloon dissector directed towards the pubis. Dissection was done from the sub-costal margin to the inguinal ligament. The superficially lying external oblique was incised in a linear fashion, at least 2 cm lateral to linea semilunaris, extending from the level of the pubis to about 2 cm over the costal margin. After doing the external oblique release bilaterally, ports are placed within the peritoneal cavity and a pneumoperitoneum is created. The hernia is reduced and the hernial defect is closed with intracorporeal 1-0 polypropylene continuous suture and the closed hernia defect covered with intraperitoneal onlay dual mesh with adhesion preventing barrier extending at least 5 cm on all sides of the defect calculated as per the original pre-closure size of the defect. If laparoscopic closure of the large defect was not possible, then the defect was simply bridged with similar IPOM with adhesion preventing barrier.

The sample size was calculated by formula sample size $n = 2(Z_\alpha+Z_{1-\beta})^2\sigma^2/\delta^2$, based on an article by Christy MR et al.[10] Assuming 90% power and 95% confidence interval, the proposed sample size for each group was 28 (total = 56). All data were collected and analysed using SPSS 19. Paired t-rest was applied for quantitative data and chi-square test was applied for qualitative data. A p-value ≤ 0.05 was considered as significant. The study was registered in a clinical trials registry – India vide CTRI/2018/03/012537 – and the work is reported in line with the STROCSS criteria.[12]

Approval to conduct this prospective observational study was obtained from academic multispeciality tertiary care single institute ethical committee.

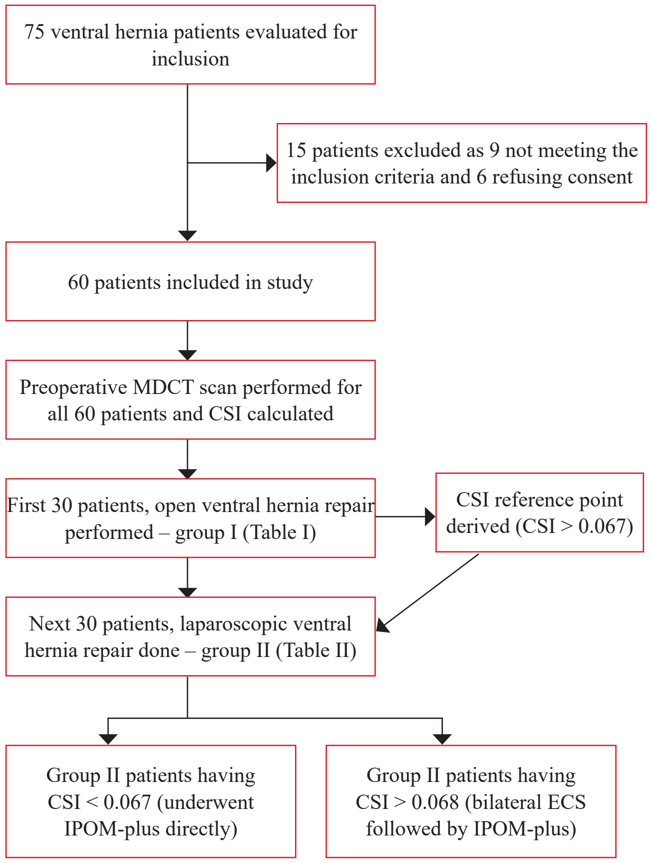

Figure 1: Consort chart showing patient assessment and treatment pathway

Results

The mean age was 42.5 years in group I and 44.2 years in group II. The male to female ratio was M12:F18 in group I to M10:F20 in group II. The AD of 60 patients ranged from 12° to 94° with mean value of 34.9° and standard error of 3.87. In group I, the mean AD was 36.41° and in group II it was 33.17° (p-value 0.65).

The CSI calculated as AD/360° ranged from 0.033 to 0.263 with overall (n = 60) mean CSI of 0.101 and standard error of 0.011. In group I mean CSI was 0.105, while in group II it was 0.098 (p-value 0.65). There was no significant difference present between the two groups regarding AD and CSI. All hernias were in stage I and II by the Petro classification.[11]

In group I, the mean transverse diameter was 9.84 cm, the mean vertical diameter was 8.83 cm and the mean area was 116.23 cm^2 on per operative assessment. In the laparoscopic group (group II), the mean transverse diameter was 9.2 cm, the mean vertical diameter was 8.6 cm and the mean area was 105.35 cm^2 on per operative assessment. In both groups it was measured on the operating table under anaesthesia before creating a pneumoperitoneum.

In the first 30 cases (open surgery group, group I), in whom hernia repair was performed by open approach, only in 12 patients (40%) was complete primary closure of defect possible without CS (sub-group IA). These 12 patients had a maximum CSI value of 0.068 which was taken as CSI reference point for the whole of group II. In the other 18 patients (60%) of group I, with CSI ≥ 0.069 (though we didn't have a patient with exact 0.069 CSI value), complete primary closure of defect was not possible, hence open bilateral CS was done in all. Even after doing CS, complete

Table I

Open group (group I)		CSI (Mean)	*n*	%
IA	Primary defect closure without tension without CS	≤ 0.068	12	40
IB	Closure of defect without tension with CS	0.069 to ≤ 0.25	14	46.7
IC	Closure of defect without tension not possible after CS	≥ 0.26	4	13.3
Total			30	100

CSI – Component separation index, CS– Component separation

Table II

Laparoscopic group (group II)			CSI (Mean)	*n*	%
IIA (CSI ≤ 0.068)	IIA1	IPOM-plus	≤ 0.044	4	13.3
	IIA2	IPOM-plus attempted but defect could not be closed hence IPOM only	0.045 to ≤ 0.068	6	20
IIB (CSI ≥ 0.069)	IIB1	Endoscopic sub-fascial component separation done followed by IPOM-plus	0.069 to ≤ 0.125	16	53.3
	IIB2	Endoscopic sub-fascial component separation done followed by attempt for IPOM-plus but defect could not be completely closed hence only IPOM done	≥ 0.126	4	13.3
Total				30	100

CSI – Component separation index, IPOM-plus – intraperitoneal onlay mesh plus direct defect closure, IPOM – Intraperitoneal onlay mesh

closure was possible only in 14 (sub-group IB) out of 18 patients (46.67% of group I patients). Their CSI value was more than 0.068 up to 0.24. In the remaining 4 patients (sub-group IC) CSI values were ≥ 0.25 and complete closure of the defect was not possible even after performing open bilateral CS. Hence, a preperitoneal adhesion preventing mesh (Class III)[10] was only placed after partially closing the defect in these 4 patients of group I (13.33% of group I patients) (Table I).

The CSI reference point of 0.068 from the open group (group I) was applied to the next 30 patients of the laparoscopic group (group II) where in all 10 patients (sub-group IIA) with CSI below 0.068, a laparoscopic defect closure and IPOM was attempted without CS. All patients with CSI value above 0.068 (66.67%) (sub-group IIB) first had bilateral (ECS) followed by an attempt at laparoscopic closure of defect with intracorporeal suturing and IPOM-plus (Table II).

Among the 10 patients with CSI below reference point of 0.068 (sub-group IIA), a laparoscopic defect closure was feasible only in 4 patients with CSI levels up to 0.044. In CSI value above 0.044, laparoscopic complete defect closure was not possible in 6 patients irrespective of CSI being less than 0.068 (open CS reference). In 16 patients who had CSI above the reference point of 0.068 (53.33 %), laparoscopic complete closure was possible after ECS, while in 4 patients who had a CSI value ≥ 0.125 (13.33%), laparoscopic complete closure of defect was not possible even after ECS. In these four cases, we could only perform laparoscopic intraperitoneal onlay meshplasty without closing the defect (Table II).

Discussion

The management of ventral hernias is continuously evolving from simple suture repair to open repairs with intraperitoneal or preperitoneal/retro rectus space mesh placement. The introduction of laparoscopic techniques and the development of composite meshes again resulted in a plethora of techniques.

Initially the laparoscopic bridging mesh repair described by Karl Leblanc in 1993 was used, but this technique is more suitable for small defects as in larger hernias mesh bulging through the defect and seroma formation are not uncommon. In addition, this type of repair can result in a functionally adynamic abdominal wall interfering with normal abdominal wall physiology.[13-15]

To overcome these difficulties, augmentation repairs were introduced, which included laparoscopic closure of hernia defect followed by IPOM, known as IPOM-plus. IPOM-plus repair results in better anterior abdominal wall physiology and function as there is no adynamic area left.[16-19] However, in large complex ventral hernias, mainly due to size and scarring, it is often difficult to close the defect without tension. CS popularised by Ramirez can facilitate complete closure of defect as it results in easy medial advancement of the rectus edge with creation of neo linea alba.[5,6,20,21]

Various methods and modifications have been described for CS in literature.[6-9] These methods can be done either by open surgery or laparoscopic method, which is known as endoscopic assisted laparoscopic component separation technique (LCST) or minimal invasive component separation technique (MICST) or simply as ECS.

ECS, originally described by Lowe et al.[6] and Maas et al.[20] is associated with decreased overall postoperative wound complication rates including superficial infections, hematoma/seroma formation, necrosis, fistula formation, and both skin and fascial dehiscence.[21-25]

As ECS is performed before intraperitoneal port placement for IPOM-plus, it is of paramount importance to know preoperatively, which hernia will need CS for complete defect closure. Transverse diameter and area of defect can be used for preoperative assessment of need for CS but this doesn't include antero-posterior dimension of patient, loss of domain, and patient's body habitus, all of which can also be important factors for a complete closure of the hernial defect.[10]

Large ventral hernias are usually diagnosed and assessed clinically. A CT scan can be a better investigation for assessment of large ventral hernia in preoperative assessment and planning. Blair et al. used defect size and abdominal wall thickness to predict the need for CS. They concluded that measurement of defect size and abdominal wall thicknesses on preoperative CT scan predict the need for a complex abdominal wall repair technique like CS.[26]

Christy et al. proposed the CSI as a three-dimensional assessment of the hernia that was an improvement on simply measuring transverse defect size or area of defect.[10] It, however, does not take account of abdominal wall scarring that develops between the layers of the abdominal wall, and may limit medial advancement hence complete closure of defect. In addition, it does not address the physiological consideration such as intraoperative peak airway pressure that may make complete midline closure dangerous even if mechanically feasible.

In their retrospective review of patients undergoing open ventral hernia repair, they reported that patients with mean CSI of 0.11 (SD = 0.06) could be closed primarily after CS. However, patients with mean CSI of 0.21 (SD = 0.04) required a meshplasty even after CS.[10]

We found that, for open approach, any ventral hernia defect having a CSI greater than 0.069 required posterior component CS for complete closure of the defect. In the laparoscopic anterior sub-fascial CS approach, even defects having CSI greater than 0.045 could not be closed laparoscopically. In open approach, defects with CSI $\geq$ 0.26 required mesh reinforcement as defect closure was not possible even after CS. In these cases, repair was with a dual mesh with adhesion preventing material. In the laparoscopic approach, a defect with CSI $\geq$ 0.126 could not be closed even after bilateral ECS and a IPOM meshplasty using adhesion preventing material was done. This overall difference in CSI between the open and laparoscopic groups was due to extra-tension created by the pneumoperitoneum during laparoscopy in spite of lowering the intraperitoneal pressure during laparoscopic suturing to only 8 mm of Hg or due to the different layered release techniques used in the open and laparoscopic groups in our study.

Conclusion

This was a CSI derivation and application study performed on a limited number of cases with few comorbidities. Despite these limitations, it has given us insight into the practical application of the index in large ventral hernia repair. We believe that CSI may be regarded as a better predictor than conventional two-dimensional defect parameters of the need for CS for complete closure of defect in both the laparoscopic and open approach. We believe it is a standardised measurement that should be used by individual expert centres to benchmark its predictive value in their setting as a planning tool for complex ventral hernia repairs.

Conflict of interest

The authors declare no conflict of interest.

Funding source

None.

ORCID

D Sharma https://orcid.org/0000-0001-8251-8484
V Upadhyay https://orcid.org/0000-0002-4384-8082
R Lal https://orcid.org/0000-0003-3862-4559

REFERENCES

1. McArdle G. Is inguinal hernia a defect in human evolution and would this insight improve concepts for methods of surgical repair? Clin Anat. 1997;10:47-55. https://doi.org/10.1002/(SICI)1098-2353(1997)10:1<47::AID-CA9>3.0.CO;2-Q.
2. Tandon A, Pathak S, Lyons NJ, et al. Meta-analysis of closure of the fascial defect during laparoscopic incisional and ventral hernia repair. Br J Surg. 2016;103(12):1598-607. https://doi.org/10.1002/bjs.10268.
3. Sharma D, Jindal V, Pathania OP, Thomas S. Novel technique for closure of defect in laparoscopic ventral hernia repair. J Minim Access Surg. 2010;6(3):86-8. https://doi.org/10.4103/0972-9941.68580.
4. Malangoni MA, Rosen MJ. Sabiston textbook of surgery: The biological basis of modern surgical practice. 19th ed. Philadelphia: Elsevier; 2012. p. 1114-39. https://doi.org/10.1016/B978-1-4377-1560-6.00046-9.
5. Ramirez OM, Ruas E, Dellon AL. 'Components separation' method for closure of abdominal-wall defects: An anatomic and clinical study. Plast Reconstr Surg. 1990;86:519-26. https://doi.org/10.1097/00006534-199009000-00023.
6. Lowe JB, Garza JR, Bowman JL, et al. Endoscopically assisted 'components separation' for closure of abdominal wall defects. Plast Reconstr Surg. 2000;105:720-9. https://doi.org/10.1097/00006534-200002000-00039.
7. Shestak KC, Edington HJD, Johnson RR. The separation of anatomic components technique for the reconstruction of massive midline abdominal wall defects: Anatomy, surgical technique, applications and limitations revisited. Plast Reconstr Surg. 2000;105:731-8. https://doi.org/10.1097/00006534-200002000-00041.
8. Jacobsen WM, Petty PM, Bite U, Johnson CH. Massive abdominal-wall hernia reconstruction with expanded external/internal oblique and transversalis musculofascia. Plast Reconstr Surg. 1997;100:326-35. https://doi.org/10.1097/00006534-199708000-00007.
9. Thomas WO III, Parry SW, Rodning CB. Ventral/incisional abdominal herniorrhaphy by fascial partition/release. Plast Reconstr Surg. 1993;91:1080-6. https://doi.org/10.1097/00006534-199305000-00017.
10. Christy MR, Apostolides J, Rodriguez ED, et al. The component separation index: Standardised biometric identity in abdominal wall reconstruction. Eplasty. 2012;12:e17.
11. Petro CC, O'Rourke CP, Posielski NM, et al. Designing a ventral hernia staging system. Hernia. 2016;20(1):111-7. https://doi.org/10.1007/s10029-015-1418-x.
12. Agha RA, Borrelli MR, Vella-Baldacchino M, Thavayogan R, Orgill DP; STROCSS Group. The STROCSS statement: Strengthening the reporting of cohort studies in surgery. Int J Surg. 2017;46:198-202.
13. Klinge U, Park JK, Klosterhalfen B. 'The Ideal Mesh?' Pathobiology. 2013;80(4):169-75. https://doi.org/10.1159/000348446.
14. LeBlanc KA, Booth WV. Laparoscopic repair of incisional abdominal hernias using expanded polytetrafluoroethylene: Preliminary findings. Surg Laparosc Endosc. 1993;3:39-41.
15. Kukleta J, Chelala E, Chowbey. 'Bridging', 'Augmentation' and reconstruction of the linea alba: Closure of the defect before IPOM. Guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias. International Endohernia Society (IEHS)-Part 1. Surg Endosc. 2014;28:2-29.
16. Agarwal B, Agarwal S, Gupta M, Mishra A, Mahajan K. Laparoscopic ventral hernia meshplasty with 'double breasted' fascial closure of hernial defect. A new technique.

J Laparoendosc Adv Surg Tech. 2008;18:222-9. https://doi.org/10.1089/lap.2007.0112.
17. Palanivelu C, Jani KV, Senthilnathan P, et al. Laparoscopic sutured closure with mesh reinforcement of incisional hernias. Hernia. 2007;11:223-8. https://doi.org/10.1007/s10029-007-0200-0.
18. Chelala E, Thoma M, Tatete B, et al. The suturing concept for laparoscopic mesh fixation in ventral and incisional hernia repair: Mid-term analysis of 400 cases. Surg Endosc. 2007;21(3):391-5. https://doi.org/10.1007/s00464-006-9014-x.
19. Chelala E, Debardemaeker Y, Elias B, et al. Eighty-five redo surgeries after 733 laparoscopic treatments for ventral and incisional hernia: adhesion and recurrence analysis. Hernia. 2010;14(2):123-9. https://doi.org/10.1007/s10029-010-0637-4.
20. Maas SM, de Vries RS, van Goor H, de Jong D, Bleichrodt RP. Endoscopically assisted 'components separation technique' for the repair of complicated ventral hernias. J Am Coll Surg. 2002;194:388-90. https://doi.org/10.1016/S1072-7515(01)01140-1.
21. Maloney SR, Schlosser KA, Prasad T, et al. Twelve years of component separation technique in abdominal wall reconstruction. Surgery. 2019;166(4):435-44. https://doi.org/10.1016/j.surg.2019.05.043.
22. Azoury SC, Dhanasopon AP, Hui X, et al. Endoscopic component separation for laparoscopic and open ventral hernia repair: a single institutional comparison of outcomes and review of the technique. Hernia. 2014;18:637-45. https://doi.org/10.1007/s10029-014-1274-0.
23. Giurgius M, Bendure L, Davenport DL, Roth JS. The endoscopic component separation technique for hernia repair results in reduced morbidity compared to the open component separation technique. Hernia. 2012;16:47-51. https://doi.org/10.1007/s10029-011-0866-1.
24. Jensen KK, Henriksen NA, Jorgensen LN. Endoscopic component separation for ventral hernia causes fewer wound complications compared to open components separation: a systematic review and meta-analysis. Surg Endosc. 2014;28:3046-52. https://doi.org/10.1007/s00464-014-3599-2.
25. Harth KC, Rose J, Delaney CP, et al. Open versus endoscopic component separation: a cost comparison. Surg Endosc. 2011;25:2865-70. https://doi.org/10.1007/s00464-010-1526-8.
26. Blair LJ, Ross SW, Huntington CR, et al. Computed tomographic measurements predict component separation in ventral hernia repair. J Surg Res. 2015;199(2):420-7. https://doi.org/10.1016/j.jss.2015.06.033.