RESEARCH ARTICLE

Predisposing Factors for Incisional Hernia after Open Abdomen Management and Timing for Repair

Authors
Fahri Yetisir, Kerim Güzel

Affiliations
Dr.Fahri YETİŞİR, MD, VM Medicalpark Ankara Private Hospital, Yüksek İhtisas University, General Surgery Department, Ankara /Turkey
Dr. Kerim Güzel, MD. Kerim Güzel. Asist. Prof. DR. Department of General Surgery , Near East University Faculty Of Medicine, 99138 Nicosia/TRNC

Correspondence
Dr.FahriYetişir
VM Medicalpark Ankara Private Hospital, Yüksek İhtisas University, General Surgery Department, Ankara /Turkey
Post code:06800
Tel:+90 536 297 48 88
Fax:03123210089
Email**:** drfahriyetisir@hotmail.com

Conflict of interest: None

Abstract

Purpose: In recent years, since the number of surviving patients managed with open abdomen (OA) has been increasing very rapidly, management of some challenging sequel such as Incisional hernia (IH) come into consideration.
We would like to report our case series of IH developing after OA management and investigate the predisposing factors for hernia occurrence following OA management.

Methods: Data of OA patients managed between 2008 and 2014 were analyzed retrospectively. Only the fascial closure achieved OA patients were included in this study and examined in terms of IH.

Results: Abdominal closure was achieved in 98(%90) of 108 OA patients. Complete closure (Fascial and skin) could be done in 63 OA patients and only skin closure was achieved in 35 OA patients. Complete closure achieved OA patients were included in this study. Mean follow up time was 20,8±13,6 months. 18.3% of them had hernias. Mean Mannheim Peritonitis Index (MPI) score and Sequential Organ Failure Assessment (SOFA) score during OA management were significantly greater in hernia group than non-hernia group. The time interval between first laparotomy to first negative pressure therapy (NPT) application (time interval to first NPT) and the length of OA management were significantly longer in hernia group than non-hernia group. IH may be repaired approximately 144 days later from OA management.

Conclusion: Time interval to first NPT application and length of OA management were significantly longer in hernia group. If fascial closure could be achieved during OA management, reasonable ratios of IH with acceptable diameter might occur.

Keywords: Open abdomen, incisional hernia, negative pressure therapy, dynamic abdominal closure, delayed abdominal closure

Introduction:

The open abdomen (OA) is one that requires a temporary abdominal closure due to the skin and fascia not being closed after laparotomy.[1] The concept of OA was introduced in the 1970s and is widely applied nowadays.[2] In recent years, the numbers of surviving patients managed with OA have been increasing very rapidly due to two important factors; one of them is the increased use of the OA treatment approach. Second one is the significant decrease in mortality rate of OA patients due to evolution in the delayed abdominal closure systems and intensive care unit (ICU) consideration.[3-5] As the number of surviving OA patients increases, management of some challenging sequels after OA treatment, such as incisional hernia (IH), constant or permanent stoma, entero-cutaneous fistula (ECF), short bowel syndrome, chronic organ failure and badly healed scar come into consideration.[4] Most important one of them is planned or unplanned IH.

Removal of cytokine-rich peritoneal fluid, decrease in bowel edema, increasing the proangiogenic growth factors, accelerating the granulation tissue formation and minimizing heat and fluid loss are the key elements for NPT in the treatment of septic OA patients. When NPT was combined with ABRA, for reapproximation of the fascial edges, high closure rates can be achieved. Mesh-mediated fascial traction methods may be more suitable in non-infected OA patients, whereas ABRA might be used in the severely infected OA patients in conjunction with NPT. Dynamic traction with ABRA in conjunction with NPT prevents fascial retraction, subscribes improvement in granulation tissue, allowing expansion and retraction during spontaneous respiratory cycle. Use of ABRA in conjunction with NPT increase the success of OA management by all this way.[6] Fernandez suggests that the addition of saline solution or hypochlorous acid solutions to OA NPWT in a programmed, controlled manner may offer the clinician an effective adjunctive therapy for the treatment of the complex septic abdomen. The use of OA irrigation in these seven patients resulted in abdominal closure while minimizing septic complication in all patients.[7] In another study, Tian showed that fluid removal therapy with torasemide combined with vacuum-assisted and mesh-mediated fascial traction provided a high early fascial closure rate for open abdomen patients.[8]

Incisional hernia is defined as abdominal wall gaps around previous incisional scars, noticeable or palpable by clinical examination or imaging.[9] They are common complications following abdominal surgery, they cause significant morbidity, impair quality of life, and are costly to treat.[10,11] Rate, diameter and shape of IH after OA management may change depending on OA etiology, diameter of OA, applied delayed closure methods and comorbidities of the patients. Although surgical correction of these IHs is possible, it has a higher complication risk and recovery takes several months.[11] Optimum delayed abdominal closures have to close all layers of abdominal wall (fascia and skin) during OA management. By excluding planned IH group, delayed fascial closure rate is widely variable ranging from 22% to 91% by using

different types of delayed abdominal closure systems. As a consequence, it could be accepted that patients who require an OA management have a substantial likelihood of developing an IH.[12] There were a few reports about IH development after OA management in the literature.

We would like to report our case series with definitive IH repair after fascial closure was achieved during OA management with NPT and abdominal re-approximation anchor (ABRA) system. We also investigate the predisposing factors of hernia occurrence following OA management.

Method:

Clinical data of the OA patients managed between 2008 and 2014 were collected and retrospectively analyzed. Complete abdominal closure (Fascial and skin closure) was achieved in some OA patients and only skin closure without fascial closure was achieved in others during OA management. Only skin closure groups are also called planned IH. Only the complete closure group was included in this study. Fascial closure was performed by NPT + ABRA or NPT+ABRA+ mesh. All patients in the fascial closure group were examined for IH and para-stomal hernia. IH was defined by clinical examination, if there was any conflict, imaging methods were also used. All data, including demographic value, etiology of OA, presence of diabetes mellitus, SOFA score, MPI score and surface area of OA wound at first NPT application, time interval between first laparotomy and first NPT application (time interval to first NPT), length of OA management were retrieved from the patient files during initial hospitalization for all patients in the study and shown for hernia group in Table 1. All these cases were managed in a regional referral center with tertiary care ICU facilities.

Time interval to IH repair was the time from the completed skin closure during OA management to the date of IH repair was recorded. Size of IH, IH repair technique, operation time, postoperative complications, length of hospital stay and postoperative follow-up period were recorded during IH treatment (Table 2).

Table 1: Demographic value , etiology of OA, BMI, malignancy, MPI, SOFA score, surface area of OA at first NPT application, time interval to first NPT application and length of OA management of patients in hernia group.

	Etiology of OA	Sex	Age (Years)	BMI	Malignancy	Surface area of OA (cm2)	Time interval to first NPT application	MPI	SOFA score	Length of OA management (day)	Midline IH	ABRA entrance side hernia	Para-stomal hernia
1	Leakage of colonic anastomosis	M	47	30	+	616	16	33	13	45	+	+	+
2	Urinary Leakage of ilial-condoit	M	65	29	+	304	11	36	10	15	+	-	+
3	Leakage of jejunal anastomosis	F	61	38	-	1330	13	43	14	66	+	+	+
4	Leakage of left colonic anastomosis	F	66	31	-	192	17	37	9	28	+	-	+
5	Leakage of pancreaticojejunostomy anastomosis	M	58	21	+	270	15	36	12	26	+	-	-
6	Leakage of ilial anastomosis after irreducible incisional hernia	F	68	25	+	266	35	37	13	39	+	+	-
7	Delayed diverticulitis peritonitis	M	54	26	-	399	15	28	5	34	+	-	+
8	Intraabdominal sepsis due to perforation of splenic abscess	M	64	27	-	272	18	33	11	31	+	-	-
9	Intraabdominal sepsis due to irreducible delayed hernia perforation.	F	78	24	-	160	10	37	6	11	-	-	+

BMI: Body mass index, IH: Incisional hernia, H:Hernioraphy ABRA: Abdominal reapproximation system, OA: Open abdomen, Open: Open approach standard operation, Lap: Laparoscopic, MH: Mesh Hernioraphy, OC: Ostomy closure, WI: Wound Infection, S: seroma.

Table 2: Time interval between the OA management and hernia repair, operation technique for hernia repair, diameter of hernias, length of hospital stay, postoperative complication and follow up time in the hernia group.

	Time interval between the OA management and hernia repair (day)	**Operation technique**	**Time of operation (min)**	**diameter of hernias (cm)**	**Length of hospital stay (day)**	**Postoperative complication**	**Follow up time after hernia repair.(month)**
1	240	Open-MH+OC	130	4	5	-	38
2	95	Open-MH+OC	115	6	8	WI	5
3	128	Open-MH+OC	135	3	5	S	10
4	155	Open-MH+OC	95	5	4	-	8
5	180	Lap- MH	65	4	2	-	4
6	65	Lap- MH	75	3	2	-	19
7	195	Open-MH+OC	165	5	7	WI	44
8	149	Lap-MH	60	3	2	-	24
9	90	Open-H+OC	65	4	4	S	11
Mean	144,1		100,5	4.1	4,3		18,1

BMI: Body mass index, IH: Incisional hernia, H: Herniorraphy , ABRA: Abdominal reapproximation system, OA: Open abdomen, Open: Open approach standard operation, Lap: Laparoscopic, MH: Mesh Herniorraphy, OC: Ostomy closure, WI: Wound Infection, S: seroma.

Surgical technique of OA management:

NPT (the V.A.C.® Abdominal Dressing System and ABThera™ Open Abdomen Negative Pressure Therapy System, KCI, an Acelity company, San Antonio, TX, USA) and ABRA were used in treatment of all OA patients in whom fascial closure was achieved. NPT was applied as following. After debridement and irrigation of the OA with warm saline, a perforated silicone sheet was placed between visceral tissue and the abdominal fascia. A foam dressing was placed over the silicone sheet, and an interface pad with attached suction tubing was applied. Negative pressure was adjusted between -50 and-125 mmHg continuously or intermittently (4 or 7 min of high negative pressure was followed by 1 or 2 min of low negative pressure respectively). The dressing was changed every 2-5 days. ABRA was applied as early as possible. A series of midline crossing elastomers were

inserted through the full thickness of the abdominal wall at a distance of approximately 5 cm from the medial fascial margin. The elastomers are aligned about 3 cm part at the center and 5 cm part at the lateral, across the defect and fixed to button anchors on both sides of OA. The optimal tension was obtained by stretching the elastomers up to 1.5-2 times their tension-free length. When all the wound edges were re-approximated completely, the fascia were sutured one by one with PDS 1-0 (Ethicon, a Johnson & Johnson company, Somerville, NJ, USA). Skin closure was performed 1–3 days after fascial closure. Approximately 1 week after fascial closure, the ABRA anchors were removed one by one.[13] If there was a large fascial defect after approximation of skin edges with ABRA, a mesh implantation was used for restoration. NPT was continued to be used on mesh at about 3-5 days and if the wound was clean, skin was closed by interrupted polyprolene suture after inserting a suction drain on top of the mesh.

If there was giant hernia with stoma, first of all, stoma reversal was performed, and hernia repair with mesh was planned 2–3 months later. If there was a small hernia, it was repaired during stoma reversal.[4]

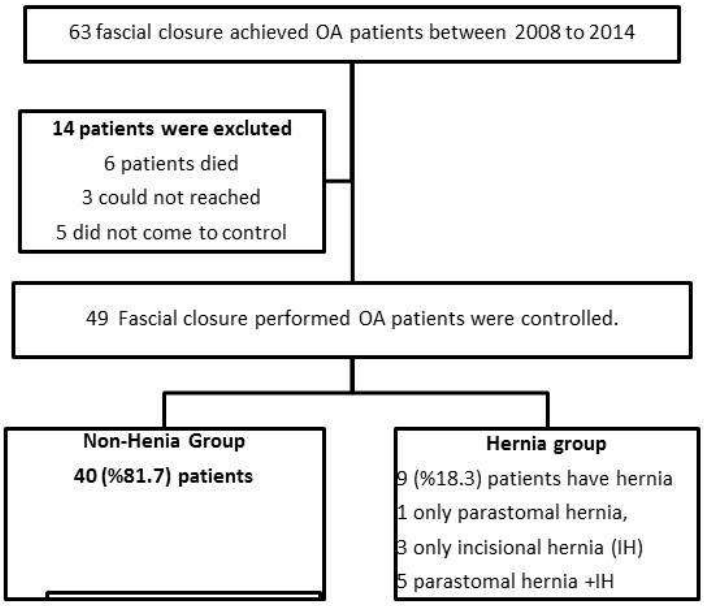
Statistical Analysis:

Data were analyzed using standard statistical methods. SPSS 22 version was used. Descriptive statistics including means, median, percentage, minimum, maximum and standard deviations were used. To evaluate the normality of variables the Shapiro-Wilk test was used. Student T test was used to compare two parametric independent variable and Mann-Withney U test was used to compare two non-parametric values between two groups. Chi-Square and fisher's exact test was used to compare ratio between two groups. Pearson Correlation was used to correlate two parametric variables. Scatter plot graphs were used to show comparative line between these two variables. P value <0.05 was accepted as statistically significant.

Results:

Abdominal closure was achieved in 98(%90) of 108 OA patients. Complete abdominal closure could be done in 63(%64) OA patients and only skin closure was achieved in 35(%36) OA patients. Mean follow up-time for OA patients was 20,8±13,6 months. 6 of these 63 OA patients were died, 3 of them could not be reached and 5 of them did not come to control. Controls of 49 patients were performed. 9 (18.3%) of these 49 patients have hernias. There were 6 parastomal hernia, 8 midline IH and 3 hernias at the elastomer entrance side of ABRA (Figure 1).

Figure1: Flow chart of the study.



Median time interval between the OA management and hernia repair was 144 (65-240) days. Median operation time for hernia repair was 95 (60-165) min and length of hospital stay was 4 (2-8) days. Laparoscopic IH repair was performed in 3 patients and open hernia repair was performed in 6 patients with para-stomal hernias (Table 2). Seroma occurred in 2 patients and superficial wound infection occurred in 2 patients. All these postoperative complications were resolved with only medical treatment. All these 4 complications can be staged as a grade I in Clavien Dindo complication scale.[14]

There were no significant differences between hernia and non-hernia groups on base of malignancy, sex, age, BMI, MPI and surface area of OA wound (Table-3). Mean SOFA and MPI score during first NPT application was significantly greater in hernia group than non-hernia group (Table-3). The time interval to first NPT and length of OA management were significantly longer in hernia group (Table-3).

Table 3: Comparison of hernia group with non-hernia group on the base of demographic value, BMI, malignancy, presence of DM, MPI and SOFA score, surface area of OA wound, length of OA management and time interval to first NPT application

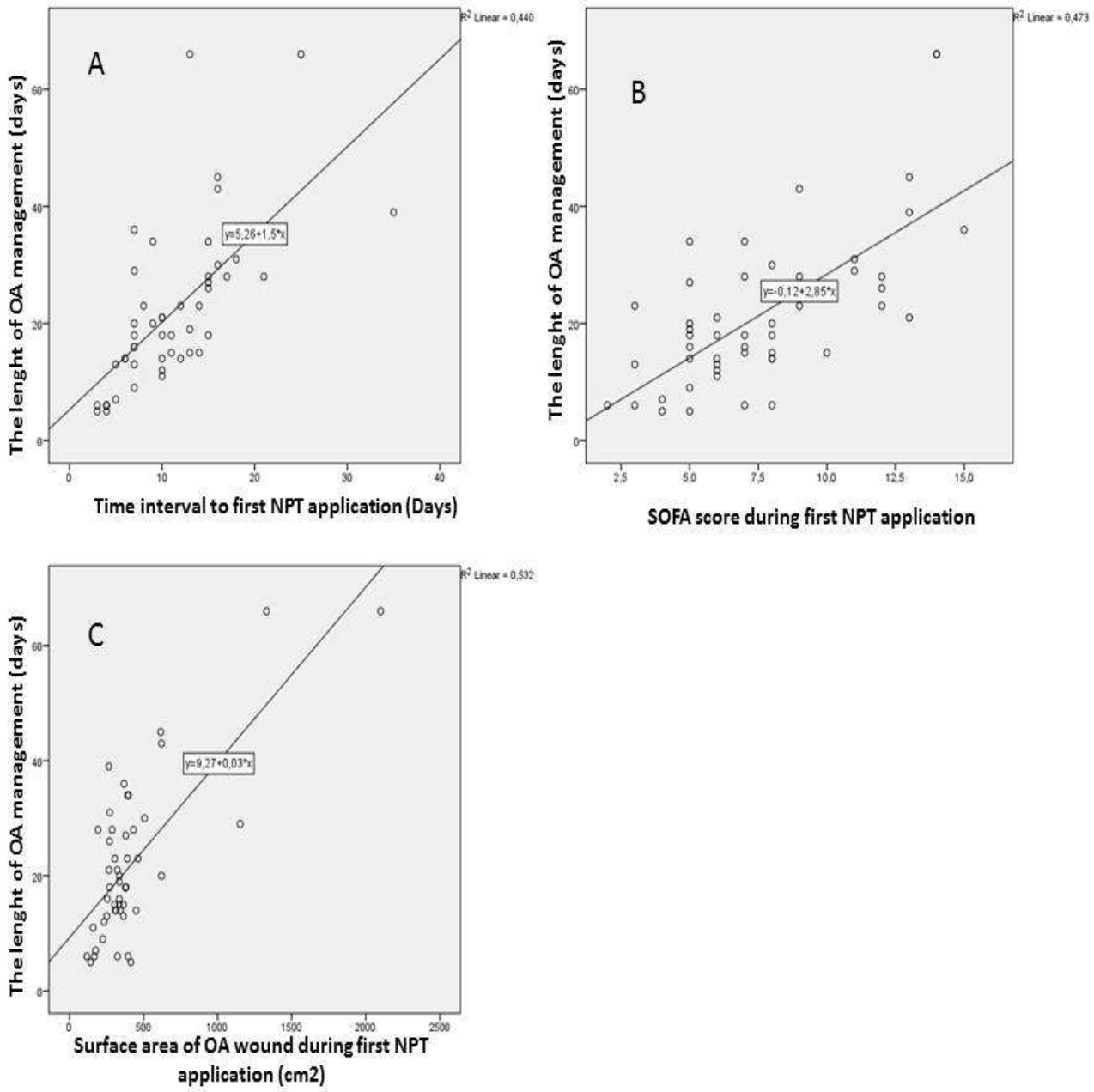
		Non-hernia group	**Hernia group**	
	N	40	9	P
age	Mean	59,03	62,33	0,530
	Std. Deviation	15,044	8,846	
sex	Female	16(%80)	4(%20)	0.545
	Male	24(%82.8)	5(%17.2)	
DM	+	5(%71.7)	2(%28.3)	0.451
	-	35(%83.3)	7(%16.7)	
Malignancy	+	11(%73.3)	4(%26.7)	0,427
	-	29(%85.3)	5(%14.7)	
BMI	Mean	27,93	27,89	0,984
	Std. Deviation	4,937	4,910	
MPI during first NPT application	Mean	28,80	35,56	0,001
	Std. Deviation	5,47	4,06	
Time interval to first NPT application	Mean	9,70	16,67	0,001
	Std. Deviation	4,93	7,36	
Length of OA management	Mean	19,23	32,78	0,006
	Std. Deviation	11,755	16,415	
SOFA score during first NPT application	Mean	7,05	10,33	0,005
	Std. Deviation	3,02	3,16	
Surface area of OA during first NPT application	Mean	405,13	423,22	0,882
	Std. Deviation	321,48	365,38	

BMI:Body mass index, DM: Diabetes mellitus, MPI: mannheim peritonitis index, NPT: Negative pressure therapy, OA: Open abdomen, SOFA: Sequential organ failure assessment , Std: Standard

There were positive correlation between length of OA management and the time interval to first NPT (r:0.663) (p<0.001) (Figure 2A), the SOFA score (r:0.688) (p<0.001) (Figure 2B) and the surface area of OA wound during first NPT application (r:0.729) (p<0.001) (Figure 2C).

The mean length of OA management is 20.0±12.1 days in non-diabetic patients and 31.8±18.2 days in diabetic patients (P=0.03). Mean OA management in diabetic patients is 11.8 days longer than non-diabetic patients CI (%95, 1.1-22.6). IH developed in 7(16.7%) of 42 non-diabetic patients and 2 (28.6%) of 7 diabetic patients (P=0.45) Diabetes mellitus does not have a significant influence on risk of hernia occurrence in this study.

Figure 2: Correlation diagram of the lenght of OA management;



Discussion:

During the last decades, the number of surviving patients after OA management increased since the prevalence of modern OA management strategies increased significantly.[15] Nevertheless, most of OA patients discharging from hospital after achieving the delayed abdominal closure heal with lots of sequel or may develop them later. Even more, management of this sequel might be more challenging. IH is one of the most important problems after OA

management. As the IH diameter increases, treatment becomes more complicated.

Covering the OA wound with a free skin graft or flap temporarily and planned ventral hernia formation was accepted as treatment option in Björck 3 and 4 OA patients. Since management of these giant ventral hernias may result in additional morbidity and mortality; early definitive fascial closure within initial hospitalization is considered to be the best option for preventing and reducing the risk of complications for these patients recently.[16-18] There are lots of factors related to OA patients, OA wound and surgical technique may influence the fascial closure rate. It is generally low after OA therapy especially for non-trauma patients.[19] After some time, IH may also develop in OA patients in whom fascial closure was achieved. In our fascial closure group, rate of IH was 18.3% (9/49) and average diameter of IH was 4.11±1.0.cm at 20,8±13,6 months follow up period. There was no mortality and major morbidity during IH operation, grade I (Clavian Dindo) postoperative complication occurred in only 4 patients. This low rate of IH in our series may be due to the fact that OA management was performed with NPT, NPT+ ABRA or NPT + ABRA + mesh by the same surgeon. Recently, combination of temporary abdominal closure methods such as NPT and sequential fascial suturing [20] or moderate fascial traction [21,22] have been used, with high fascial closure rates reported, even in non-trauma OA patients.[19] Fascial closure with NPT and delayed abdominal closure systems during OA management has lots of advantages. Lower rate of IH development with reduced size is one of them.

Bosanquet et al reported the prevalence of IHs after midline incision was 12.8% (range: 0 to 35.6%) at mean follow up of 23.7 months in a systematic review and meta-regression of 14,618 patients from 83 patients groups after surgery via a midline laparotomy.[23] They showed age, obesity, infection and major emergency surgery like abdominal aorta aneurysm repair as predisposing factors for IH occurrence. OA patients should be operated emergently, they might be septic and several reentries had to be performed, all of which are predisposing factors for IH development. The OA management is based on eliminating secretions, protecting the viscera and avoiding lateral musculoaponeurotic retraction. NPWT encounters all above requirements (grade 1B) according with 2013 WSACS Guidelines.[1]

The success of final closure rate is related to the formerly used TAC. If the granulation tissue is sufficiently well developed after NPWT, polypropylene meshes can be applied over granulated tissue. Dual meshes can be used as an alternative by suturing to the aponeurotic edges and applied over the viscera. Biological materials may be use also, but they can give rise to postoperative complications due to graft necrosis. More expensive modern cross-linked and non-cross-linked meshes, manufactured in the laboratory, are another possible solution for closure of OA.[24-27]

There is no enough information in literature about how long should be waited for the repairment of IH after OA management. In this study 9 IH cases were operated, IH

operation was performed after approximately 144 days' from OA management without mortality and major morbidity.

We found very few studies describing hernia incidence after OA therapy systematically. Consequently, to analyze the hernia development after successful delayed fascial closure has become important.[19] In this study, mean follow up-time for OA patients was 20.8 months, the occurrence ratio of IH after successful closure of OA by using NPT and ABRA system was 18,3%. Diameters of these hernias were very small and treatment of them was not so difficult. Laparoscopic hernia repair can also be applied successfully, if the surgeon was experienced. [27] In this type of approach, at the end of OA management abdominal domain was preserved with the rectus muscle functioning in its original midline position and by this way more functional and comfortable abdominal wall could be provided.

We found that there was a distinct correlation between IH occurrence and MPI and SOFA score at the first NPT application. In the hernia group, the length of OA management and the time interval to first NPT application was longer than non-hernia group. As the time interval to first NPT and the length of OA management prolongs, the incidence of IH after OA management also increases.

In this study, there are some limitations; most important one of them is that these OA patients were not a homogenous group and so many factors can influence the result of this type of patients, the other is that number of patients treated with OA is small for the statistical analyses. To reach a definitive conclusion, we need so many prospective randomized, multicenter studies with high number of OA patients.

Conclusion:

If fascial closure could be achieved during OA management by NPT and ABRA application, reasonable ratios of IH with acceptable diameter might occur. Positive correlation was found between the duration of OA management and time interval to first NPT application, surface area of OA wound, SOFA and MPI score of the patients at the fist NPT aplication. As the duration of OA management prolongs, the incidence and diameter of IH increases.

Surface area of OA wound, SOFA and MPI scores are not changeable parameters but time interval to first NPT application and duration of OA management should be shortened. Application of NPT has to be started as soon as possible in OA management.

References:

1. Kirkpatrick AW, Roberts DJ, De Waele J et al. Intra-abdominal hypertension and the abdominal compartment syndrome: updated consensus definitions and clinical practice guidelines from the World Society of the Abdominal Compartment Syndrome. *Intensive Care Med*. 2013);39(7):1190–1206.

2. Cheatham ML, Safcsak K Is the evolving management of intra-abdominal hypertension and abdominal compartment syndrome improving survival? *Crit Care Med.* 2010;38:402–7

3. Stone HH, Strom PR, Mullins RJ. Management of the major coagulopathy with onset during laparotomy. *Ann Surg*.1983;197(5):532-5.

4.Yetişir F, Şarer AE, Acar HZ, Çiftciler E. The Reversal of Stoma Following Open Abdomen Management. *Indian J Surg.* 2016;78(3):182-6. doi: 10.1007/s12262-015-1336-2. Epub 2015 Sep 5.

5.Yetişir F, Şarer AE, Acar HZ, Aygar M. Delayed Closure of 61 Open Abdomen Patients Based on an Algorithm. *Indian J Surg*; 2017;79(1):38-44. doi: 10.1007/s12262-015-1422-5. Epub 2015 Dec 23.

6. Sarer AE, Yetisir F, Aygar M, Acar HZ, Polat Y, Osmanoglu G. Intra-abdominal Pressure Monitoring in Open Abdomen Management with Dynamic Abdominal Closure. *Indian J Surg*. 2017;79(5):384-389. doi: 10.1007/s12262-016-1491-0. Epub 2016 May 13.

7. Fernandez L G, Sibaja Alvarez P, Kaplan M J, et al. Application of NegativePressure Wound Therapy with Instillation and Dwell Time of the Open Abdomen: Initial Experience. *Cureu.* 2019*;* 11(9): e5667. DOI 10.7759/cureus.5667

8. Tian W, Huang Q, Yao Z et al. A preliminary prospective study of patients who underwent vacuum-assisted and mesh-mediated fascial traction techniques for open abdomen management with negative fluid therapy: An observational study. *Medicine (Baltimore).* 2019;98(35):e16617.

9. Muysoms FE, Miserez M, Berrevoet F, Campanelli G, Champault GG, Chelala E, et al. Classification of primary and incisional abdominal wall hernias. *Hernia*.2009;13:407–14.

10. Burger JW, Luijendijk RW, Hop WC, Halm JA, Verdaasdonk EG, Jeekel J. Long-term follow-up of a randomized controlled trial of suture versus mesh repair of incisional hernia. *Ann Surg*.2004;240:578–83

11. Boele van HP, Wind J, Dijkgraaf MG, Busch OR, Goslings JC. Temporary closure of the open abdomen: a systematic review on delayed primary fascial closure in patients with an open abdomen. *World J. Surg.*2009;33(2):199–207.

12. Petro CC1, Como JJ, Yee S et al. Posterior component separation and transversus abdominis muscle release for complex incisional hernia repair in patients with a history of an open abdomen. *J Trauma Acute Care Surg.*2015;78(2):422-

13. Salman A.E, Yetişir F, Aksoy M, Tokaç M, Yıldırım M.B, Kılıç M. Use Of Dynamic Wound Closure System In Conjunction With Vacuum Assisted Closure Therapy In Delayed Closure Of Open Abdomen. *Hernia*.2014;18:99-104 https://doi.org/10.1007/s10029-012-1008-0

14. Dindo D, Demartines N, Clavien PA. Classification of Surgical Complications A New Proposal With Evaluation in a Cohort of 6336 Patients and Results of a Survey. *Ann Surg*.2004;240(2):205–13.

15. Lambertz A, MihatschCh, Röth Aetal. Fascial closure after open abdomen: initial indication and early revisions are decisive factors-a retrospective cohort study. *Int J Surg*.2015;13:12-6.

16. Scott BG, Feanny MA, Hirshberg A. Early definitive closure of the open abdomen: a quiet revolution, *Scand. J. Surg*.2005;94: 9–14,

17. Scott BG, Welsh FJ, Pham HQ et al. Early aggressive closure of the open abdomen, *J Trauma*.2006 ;60:17-22.

18. Koss W, Ho HC, Yu M et al. Preventing loss of domain: a management strategy for closure of the "open abdomen" during the initial hospitalization. *J Surg Educ*.2009;66(2):89-95

19. Bjarnason T, Montgomery A, Ekberg Oetal. One-year follow-up after open abdomen therapy with vacuum-assisted wound closure and mesh-mediated fascial traction. *World J Surg*.2013;37:2031-8.

20. Cothren CC, Moore EE, Johnson JL et al. One hundred percent fascial approximation with sequential abdominal closure of the open abdomen. *Am J Surg*.2006;192:238–42

21. Petersson U, Acosta S, Bjorck M. Vacuum-assisted wound closure and mesh-mediated fascial traction: a novel technique for late closure of the open abdomen. *World J Surg*.2007;31:2133–2137.

22.Yetisir F, Salman AE, Ozdemir F, Durak D, Ozlu O, Kilic M (2013) Modified application of dynamic wound closure system in the management of septic open abdomen. *World Journal of Trauma and Critical Care Medicine*.2013; 1:1-8.

23. Bosanquet DC, Ansell J, Abdelrahman T et al. Systematic Review and Meta-Regression of Factors Affecting Midline Incisional Hernia Rates: Analysis of 14,618 Patients. *PLoS One*.2015:21;10(9):e0138745. doi: 10.1371/journal.pone.0138745

24. Slater NJ, van der Kolk M, Hendriks T, van Goor H, Bleichrodt RP. Biologic grafts for ventral hernia repair: a systematic review. *Am J Surg*. 2013;205(2):220–30

25. Deeken CR. Biologic Mesh: Classification and evidence-based critical appraisal. *Hernia Surgery*. 2016;61(69)

26. Popescu GA, Bara T, Rad P. Abdominal Compartment Syndrome as a Multidisciplinary Challenge. A Literature Review. *J Crit Care Med (Targu Mures).* 2018 Oct 1;4(4):114-119. doi: 10.2478/jccm-2018-0024. eCollection 2018 Oct.

27. Yetişir F, Sarer AE. Operative Management of Enteroatmospheric Fistula in Björck 4 Open Abdomen Patients by the Help of Laparoscopic Lateral Approach. *Indian J Surg*. 2017;79(2):173-176. doi: 10.1007/s12262-017-1595-1. Epub 2017 Jan 20. PMID: 28442849

