Outcomes of synthetic mesh in reconstruction of complex abdominal wall defects

Samir A. Ammar, *MD*

Department of General Surgery, Assiut University Hospital, Assiut, Egypt.

Introduction: *The optimal management of complex abdominal wall defects (CAWD) is still undefined. The purpose of this study is to evaluate the use of synthetic mesh to treat CAWD.*

Patients and methods: *Patients with CAWD treated by polypropylene mesh (PP) at a university hospital between January 2005, and June 2012 were reviewed. The types of repair as well as clinical, operative, and follow-up data were analyzed. The primary outcome variables were surgical site occurrences (SSO) and hernia recurrence.*

Results: *One hundred fifty-three patients were included in this study. The average age was 56 years, with an average body mass index (BMI) of 32 kg/m^2. Forty-six percent were women. A staged approach was needed in 28 patients (18.3%) with wound dehiscence and defects that could not be closed. The overall complication rate was 31.3% (48/153). The rate of SSO was 20.2%. The hernia recurrence or bulge was observed in 11% (17/153). Factors associated with SSO included BMI, bacterial contamination, diabetes mellitus, and emergency procedures. Hernia recurrence was significantly associated with female gender, size of the defect, BMI, liver cirrhosis and surgical SSO. Different techniques of synthetic mesh placement were not found to have a statistically significant difference predicting SSO or hernia recurrence.*

Conclusion: *The reconstruction of CAWD frequently requires composite and staged procedures. PP mesh can be used with favorable outcomes even in contaminated defects. Synthetic meshes that become infected can be salvaged with local wound measures and antibiotics. SSO is found to be significant predictors of hernia recurrence.*

Key words: *Mesh repair, abdominal wall reconstruction, hernia recurrence.*

Introduction:

The aims of abdominal wall reconstruction are to reestablish the integrity of the myofascial layer, provide durable cutaneous coverage, and to achieve acceptable surface contour.[1] Complex abdominal wall defects (CAWD) refer to situations where simple ventral hernia repair is not feasible because the defect is very large, there is a concomitant infection or failed previous repair attempt, or if there is not enough original skin to cover the repair.[2,3] Often the complexity is identified before operation, but in some cases, events that are encountered (e.g., bowel gangrene) intra-operatively may promote a hernia from one that was regarded preoperatively as simple to one being complex[3]. Numerous methods are available for abdominal wall reconstruction depending upon the clinical situation, which include presence or absence of contamination, location and size of defect, and soft tissue condition. The optimal management of CAWD is still undefined. The objective of this study is to evaluate the use of synthetic polypropylene (PP) mesh in the repair of CAWD.

Patients and methods:

This study included adult patients with CAWD undergoing operative reconstruction using PP at Assiut University Hospital between January 2005 and December 2012. Medical records were analyzed for patient demographics, including age, sex, body mass index (BMI), comorbidity, and outcome measures such as wound complications

and recurrence. The criteria used to define patients with CAWD included one or more of the following: (1) width greater than15 cm; (2) recurrence with a previous mesh; (3) cutaneous infection or absence of stable skin coverage; and (4) emergency surgery with bowel resection. Hernia width was calculated based on the intra-operative measurement of the horizontal distance in cm between the lateral margins of the fascial defect. Patients were excluded from analysis if they had post-traumatic defects, defects resulting from excision of abdominal wall tumors, or defects after gangrene of abdominal wall.

Surgical techniques:

All patients with ventral hernias underwent exposure of the hernia sac and fascial margins of the defect through an elliptical skin incision incorporating any redundant skin and fat as well as the cutaneous scars. The musculo-fascial margins of the defect were defined clearly. A low-tension closure of the defect was performed with or without a relaxation incision or component separation. Mesh placement was performed according to the discretion of the surgeon. For cases in which the fascia could not be approximated without tension, the mesh was placed as a bridge with autologous tissue transposition; this host tissue barrier consisted of the greater omentum and a peritoneal flap derived from the hernia sac. The mesh should lie flat, with neither folds nor tension, and be secured to the fascia with non-absorbable sutures.

In patients with skin infection or necrosis **Figure(1),** the lesion was managed with antibiotic treatment, debridement of necrotic tissue and local wound care. When the inflammatory signs disappeared and a negative culture was obtained, patients were considered for definitive surgery. Giant ventral hernias cause overabundance or sagging of the overlying skin. Contouring procedure was performed at the time of the hernia repair; as the goal is to restore an aesthetic shape to the abdominal wall **Figure(2,3).** Staged repair or planned ventral hernia was needed in critically ill patients with intra-abdominal sepsis and contaminated defects that could not be closed. These defects can't be closed by tension sutures due to edema of the viscera or relative deficiency of tissue. Methods of staged repair included skin only closure **Figure(4)**, split-thickness skin graft **Figure(5)**, or spontaneous epithelization by secondary intention.

Postoperative management and follow-up:

The patients were closely observed postoperatively for adequate pain control, urine output, and blood gases. As soon as practical, the patient was raised to about 45-degree flexion of the trunk in order to allow maximum pulmonary ventilation and to decrease tension on repair. The intravenous infusion was continued until return of bowel sounds. Semisolid and solid diets were then gradually advanced. The patient remained catheterized until he/she were able to get out of bed. The drains were removed when the output was less than 50 cc within the 24-hours period. Patients were discharged when they recovered their autonomy, pain was well tolerated, and the surgical team was satisfied that there were no immediate complications. Outpatient follow-up was at 1, 3, 6, and 12 months, and yearly thereafter. Follow-up assessment of hernia recurrence was based on physical examination± abdominal imaging.

Endpoints:

The primary outcome variables for this study were surgical site occurrences (SSO) and hernia recurrence. SSO were defined as development of an infection at 30 days; formations of a seroma, hematoma or fistula; or wound dehiscence.[4,5] Seroma was defined as accumulation of noninfected fluid after removal of drains, which need aspiration, while surgical site infection was reported if there is purulent drainage from the incision or local signs and symptoms of inflammation or infection. Abdominal bulge was defined as an abnormal protrusion of the abdominal contour, with no underlying defect, as observed in a postoperative physical examination with the patient in the standing position. A recurrent hernia was defined as a fascial defect palpable on physical examination and/or visible on

the CT scan. Wound dehiscence or wound disruption is separation of the edges of the wound with protrusion or evisceration of abdominal contents.

Statistical analysis

Data were analyzed using a commercially available software program (SPSS 9 for Windows). Differences between groups were compared using chi-square test. Continuous data were analyzed using Student's t-test. P-values of less than 0.05 were regarded as significant.

Results:

One hundred fifty-three patients were included in this series. The average age was 56 years, with an average body mass index (BMI) of 32 ± 6.6 kg/m^2. Mean hospital stay was 7.9 ± 6.5 days. The mean follow-up was 28 months (range, 6-72). The operation was performed as an emergency procedure in 100 patients (65%). The characteristics of patients, defects, and repair are shown in **Table (1).** A staged approach was needed in 28 patients (18.3%) with wound dehiscence and defects that could not be closed. The overall complication rate was 31.3% (48/153).

Analysis of surgical site occurrences:

SSO were identified in 31 of 153 (20.2%) patients. Twenty patients (13%) developed surgical site infection, and were managed with antibiotics and local wound care. Eight patients (5.1%) had seroma in the subcutaneous tissue and were treated with percutaneous aspiration and external garment compression. Three patients had exposure of the mesh. After a brief course of antibiotics, outpatient debridement and treatment with repeated dressings, the wound healed by secondary intention within 4-6 weeks. Excision of exposed part of the mesh was needed in two patients. Complete removal of the mesh was not needed in any of these patients, and none developed chronic mesh infection. Defect size and mesh placement technique were not found to have a statistically significant difference predicting SSO **Table (2)**. Factors that significantly predict SSO included diabetes mellitus, liver cirrhosis, BMI, bacterial contamination, and emergency operation.

Analysis of hernia recurrence and bulge:

Eleven patients had hernia recurrence, and six patients had abdominal wall bulge. Patient's age, mesh placement technique, bacterial contamination, and emergency operation were not found to have a statistically significant difference predicting hernia recurrence or bulge **Table (3)**. Patients with liver cirrhosis, high BMI, or with defect size greater than 15 cm were more likely to have hernia recurrence and bulge. Women had a higher recurrence rate than men. Hernia recurrence was more common among patients who had SSO.

Discussion:

In reconstruction of abdominal wall defects, the surgeon must take into consideration local wound condition, optimize the utility of remaining tissues, reinforce the abdominal wall with mesh, and provide healthy skin coverage. Tension-free repair technique has gained wide acceptance, and surgeons have developed various techniques to achieve this purpose; such as prosthetic mesh repair, autologous tissue grafts repair, acellular dermal matrix patch repair, and components separation technique. Mesh augments the strength of the weakened abdominal wall and achieves a tension-free repair. To decrease tension and to reduce the size of the mesh needed, it is sometimes combined with a component separation. Components separation technique allows enlargement of the abdominal wall surface by separating muscle layers without damaging the innervation or blood supply to the muscles.[6]

The principles of ventral hernia repair are optimization of the patient, preparation of the wound, reapproximation of the rectus muscles along the midline to the extent possible, and the use of appropriate prosthetic repair material to reinforce the closure.[7] Optimization of the patient is done by weight reduction, improvement of nutritional status, adjustment

of any comorbidity, and smoking cessation. There are two stages of preparation of wounds that may complicate cutaneous coverage of abdominal hernia. The first occurs prior to surgery; this stage may include percutaneous drainage of any abscesses, management of the lesion with antibiotic and debridement of necrotic tissue. When the inflammatory signs disappear and a negative culture is obtained, definitive surgery is considered. The second stage occurs in the operating room; sharp debridement of all devitalized or infected tissue to reduce the bioburden of the wound is critical, and contaminated wounds should be cleaned by lavage.[8] If the bioburden can be successfully managed, then immediate reconstruction can be performed.[7] Otherwise, definitive repair is postponed.

In the era of ''damage control'' surgery following severe abdominal trauma or sepsis, an increasing number of patients is treated with an open abdomen technique. Planned ventral hernia refers to a management strategy where the abdominal fascial layer has been left unclosed and the viscera are covered with original or grafted skin.[9] The short-term aims of temporary abdominal closure include protection of the viscera and preventing fistula formation, and enabling safer future fascial and skin closure.[10] In this study, planned ventral hernia was needed in 28 patients (18.3%) with abdominal wound dehiscence. Patients with abdominal wound dehiscence in the immediate post-operative period have wound infection, visceral edema and poor general condition. Sometimes, these defects cannot be closed by tension sutures due to edema of the viscera or relative deficiency of tissue. Leaving the fascia open (laparostomy) may be the optimal approach in treating such patients to avoid abdominal compartment syndrome and to improve survival. In these situations, the hernia is a favorable outcome with the aim of repairing the hernia at a later stage when it is safe, possible and tolerated by the patient.

When a synthetic mesh is used for repair of CAWD, the following conditions need to be met: availability of normal skin to cover the mesh, separation of the underside of the mesh from viscera by the greater omentum and a peritoneal flap derived from the hernia sac to avoid bowel erosion with fistula formation or excessive adhesions. The ideal mesh should be non-absorbable, biocompatible, preserve the physiological elasticity of the abdominal wall and allow proper integration with the surrounding tissue.[11] Monofilament PP meshes can resist infection with higher bacterial clearance compared to multifilament meshes and composite meshes with an anti-adhesive barrier.[12] Unique properties of synthetic PP material should be considered when evaluating a prosthetic mesh for high-risk hernia repair.

SSO are difficult to completely avoid in patients with CAWD. In this study, many patients had risk factors for SSO such as high BMI, multiple comorbidities, and bowel resection. The reported rate of SSO is 20.2%. Patients with surgical site infection are successfully treated by antibiotics in combination with repeated dressing. PP mesh was salvaged in all patients with SSO; only two patients required partial mesh excision. The decision for mesh removal is determined clinically. Grossly infected mesh that is unincorporated into surrounding tissue should be removed when found.[13] A number of studies, including this study, challenge the surgical dictum that a synthetic mesh is contraindicated in a contaminated field during open abdominal wall reconstruction. Several series have reported favorable outcomes of synthetic mesh used in contaminated fields.[14,15] Two prospective randomized trials of lightweight PP mesh placed prophylactically at the time of stoma creation in the retro-rectus position have reported excellent long-term results[16,17]. Other investigators continued to share their successful experience with synthetic mesh in contaminated fields.[15,18-19]

In acutely strangulated hernia, Zafar and colleagues[20] noted a 38% wound complication rate when a bowel resection was performed versus 28% without bowel resection. Despite slightly higher infections with bowel resection, no mesh required removal, even in five patients who developed

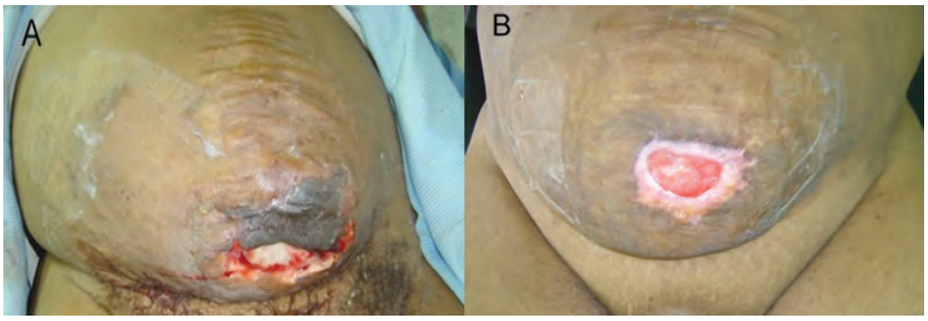

Figure (1): Incisional hernia with necrosis of skin coverage (a). The same patient after débridement of necrotic tissue and local wound care for 3 weeks.

Figure (2): Reoperative front and lateral views (a,b) of a giant complicated umbilical hernia in patient with liver cirrhosis. Postoperative view of the same abdominal wall after reconstruction using synthetic polypropylene mesh (c).

Figure (3): Preoperative front and lateral views (a,b) of incisional hernia with ulceration of skin coverage. Postoperative view of the same patient (c).

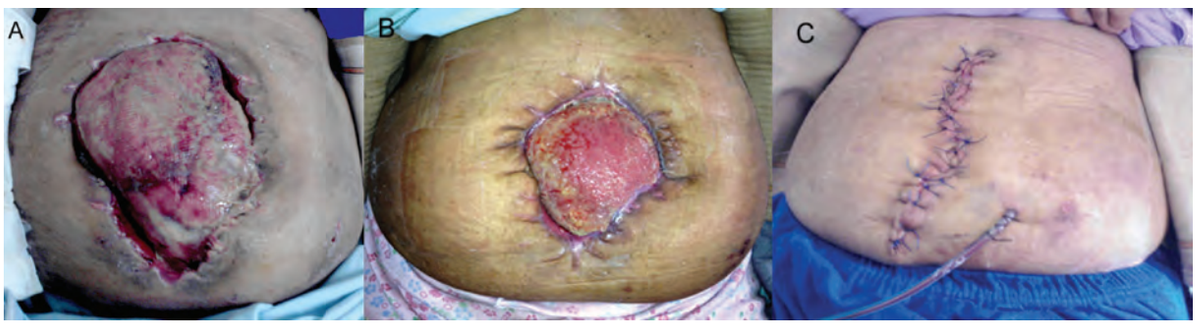

Figure (4): Patient with liver cirrhosis and mesenteric vascular occlusion developed burst abdomen on the 9th postoperative day (a). The same patient after 3 weeks of local wound care (b). The same patient after skin only closure (c).

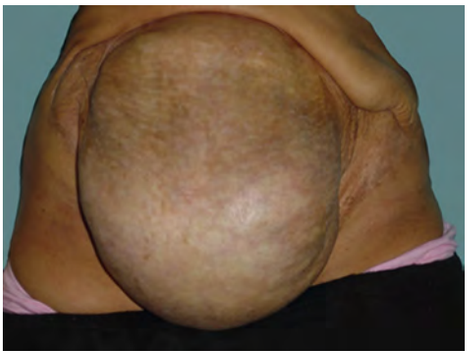

Figure (4): A case of planned ventral hernia with split-thickness skin graft.

Table 1. Patient, defect, and repair characteristics.

Characteristics	Data	%
Patients (n)	153	
Age (year)	56±15	
Gender		
Male	82	53.5
Female	71	46.5
Etiology of the defect		
Ventral hernias		
Size >15 cm	27	17.7
Previous mesh repair	9	5.8
Trophic skin lesions	23	15
Gangerenous bowel resection	66	43
Wound dehiscence a	28	18.3
Comorbidity		
Liver cirrhosis	46	30
Obesity	34	22.2
Diabetes mellitus	33	21.5
Active smoking	33	21.5
COPD b	11	7.1
Renal insufficiency	7	4.5

Characteristics	Data	%
Emergency	100	65.3
Elective	53	34.6
Auxiliary procedures		
Bowel resection	66	43
Fascial partition release	25	16.3
Partial skin graft	3	1.9
Mesh placement		
Onlay	83	54.2
Underlay	43	28
Sandwich technique	20	13
In- lay	4	2.6
Unknown	3	1.9
Postoperative complications		
Surgical site occurrences		
Surgical site infection	20	13
Seroma	8	5.1
Mesh exposure	3	1.9
Late postoperative complication		
Bulge	6	3.9
Recurrence of hernia	11	7.1

a With defects that could not be closed
b COPD: Chronic obstructive pulmonary disease

deep infections. On the other hand, Abd-Ellatif and colleagues[21] used PP mesh repair for strangulated hernia. They experienced a low rate of wound infections between the patients with and without bowel resection. Although the wound complication rate may be increased with bowel resection, the mesh never required removal.[22,23] Bessa and Abdel-Razek[24] analyzed the combined results of prosthetic mesh repair in cases of strangulated hernias available in the literature. Combined analysis of 572 patients support the safety of prosthetic mesh for the repair of hernias that present strangulated, requiring bowel resection.

Two factors are common between the risk factors for SSO and hernia recurrence; high BMI and liver cirrhosis. Another important finding of this study is the role of SSO on predicting hernia recurrence and bulge. This finding is similar to that reported by other studies.[5,25] Mesh placement techniques are not found to have a statistically significant difference in SSO or hernia recurrence. In Cochrane Systematic Review, trials comparing onlay and sublay positions for

Table 2. Factors affecting surgical site occurrences.

	With surgical site occurrence (n. 31)	No surgical site occurrence (n. 122)	P value
Male Female	15 16	67 55	0.51
Mean age	57.3	54.5	0.20
Mean body mass index	34.2	31.1	0.0464*
Operative field Clean With bacterial contamination	 6 25	 47 75	 0.045*
Emergency Elective	25 6	75 47	0.045*
Defect size >15 cm ≤15cm	 9 22	 20 102	0.108
Mesh placement Onlay Underlay Sandwich technique In- lay Unknown	 14 9 6 1 1	 69 34 14 3 2	 0.708
Comorbidity Liver cirrhosis Diabetes mellitus Active smoking	 14 13 10	 32 20 23	 0.04* 0.002* 0.105

**** Statistically significant***

incisional hernias showed no difference in recurrences.[26] Recurrence after abdominal wall hernia repair has been shown to be correlated with factors that cause poor wound healing, such as obesity,[27] diabetes,[28] and liver cirrhosis. In the present study, smoking is not found to be a significant predictor of SSO or hernia recurrence. In a study by Rosen et al,[29] there was no significant difference with respect to recurrence or wound morbidity between smokers and nonsmokers. Women had a higher recurrence rate than men in this study. In consistent with this result, Lin et al[30] reported significantly higher recurrence rate in female gender.

Although retrospective study is good for analyzing multiple outcomes, and it can accumulate data for a large number of patients, an inherent weakness of the study is the potential for selection bias and the liability for great deal of missed data. The accuracy of the data collected is dependent on the quality of information in the medical record. In this study, cases with synthetic PP mesh in CAWD repairs are selected. The type of PP mesh, light weight or heavy weight, is not known in most cases and consequently, excluded from analysis. There are other patients with CAWD who had repair either without mesh or with other types of meshes and were excluded from this study.

Conclusion

The management of CAWD is challenging and frequently requires composite and staged procedures. Each repair should be tailored to both the characteristics of the defect and the patient. PP mesh can be used with favorable outcomes even in contaminated defects. Mesh that becomes infected can be salvaged with local wound measures and antibiotics. SSO is found to be significant predictors of

Table 3. Factors affecting recurrence or bulge after repair.

	Recurrence or bulge (n. 17)	No recurrence or bulge (n. 136)	P value
Male Female	5 12	77 59	0.03*
Mean age	58.7	50.6	0.182
Mean body mass index	34.3	30.4	0.010*
Operative field Clean With bacterial contamination	 3 14	 50 86	 0.118
Mesh placement Onlay Underlay Sandwich technique In-lay Unknown	 9 4 3 1 0	 74 39 17 3 3	0.80
Emergency Elective	11 6	89 47	0.94
Defect size >15 cm ≤15cm	 7 10	 22 114	0.013*
Comorbidity Liver cirrhosis Diabetes mellitus Active smoking	 10 5 6	 36 28 27	 0.006* 0.404 0.144
Surgical site occurrence	7	24	0.02*

**** Statistically significant***

hernia recurrence.

Reference

1- Butler CE, Baumann DP, Janis JE, Rosen MJ: Abdominal wall reconstruction. *Curr Probl Surg* 2013; 50: 557–586.

2- Leppäniemi A, Tukiainen E: Reconstruction of complex abdominal wall defects. *Scand J Surg* 2013; 102: 14–19.

3- Slater NJ, Montgomery A, Berrevoet F, Carbonell AM, Chang A, Franklin M, Kercher KW, Lammers BJ, Parra-Davilla E, Roll S, Towfigh S, van Geffen E, Conze J, van Goor: Criteria for definition of a complex abdominal wall hernia. *Hernia* 2013 [Epub ahead of print] DOI.10.1007/s10029-013-1168-6.

4- Kanters AE, Krpata DM, Blatnik JA, Novitsky YM, Rosen MJ: Modified hernia grading scale to stratify surgical site occurrence after open ventral hernia repairs. *J Am Coll Surg* 2012; 215: 787–793.

5- Berger RL, Li LT, Hicks SC, Davila JA, Kao LS, Liang MK: Development and validation of a risk-stratification score for surgical site occurrence and surgical site infection after open ventral hernia repair. *J Am Coll Surg* 2013; 217 (6): 974–982.

6- 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(3): 519–526.

7- Ventral Hernia Working Group, Breuing K, Butler CE, Ferzoco S, Franz M, Hultman CS, Kilbridge JF, Rosen M, Silverman RP, Vargo D: Incisional ventral hernias: Review of the literature and recommendations regarding the grading and technique of repair. *Surgery*

2010; 148(3): 544–558.
8- Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR: Guideline for prevention of surgical site infection. Hospital Infection Control Practices Advisory Committee. *Infect Control Hosp Epidemiol* 1999; 20: 250–278.
9- Leppäniemi A, Tukiainen E: Planned hernia repair and late abdominal wall reconstruction. *World J Surg* 2012; 36: 511–515.
10- Scott BG, Feanny MA, Hirshberg A: Early definitive closure of the open abdomen: A quiet revolution. *Scand J Surg* 2005; 94: 9–14.
11- Schumpelick V, Klinge U, Junge K, Stumpf M: Incisional abdominal hernia: The open mesh repair. *Langenbecks Arch Surg* 2004; 389(1): 1–5.
12- Blatnik JA, Krpata DM, Jacobs MR, Gao Y, Novitsky YW, Rosen MJ: In vivo analysis of the morphologic characteristics of synthetic mesh to resist MRSA adherence. *J Gastrointest Surg* 2012; 16: 2139–2144.
13- Morris LM, LeBlanc KA: Components separation technique utilizing an intraperitoneal biologic and an onlay lightweight polypropylene mesh: ''A sandwich technique''. *Hernia* 2013; 17: 45–51.
14- Krpata DM, Blatnik JA, Novitsky YW, Rosen MJ: Evaluation of high-risk, comorbid patients undergoing open ventral hernia repair with synthetic mesh. *Surgery* 2013; 153: 120–125.
15- Souza JM, Dumanian GA: Routine use of bioprosthetic mesh is not necessary: A retrospective review of 100 consecutive cases of intra-abdominal midweight polypropylene mesh for ventral hernia repair. *Surgery* 2013; 153: 393–399.
16- Brandsma HT, Hansson BM, V-Haaren-de Haan H, Aufenacker TJ, Rosman C, Bleichrodt RP: PREVENTion of a parastomal hernia with a prosthetic mesh in patients undergoing permanent end-colostomy; the PREVENT-trial: Study protocol for a multicenter randomized controlled trial. *Trials* 2012; 13: 226.
17- Jänes A, Cengiz Y, Israelsson LA: Preventing parastomal hernia with a prosthetic mesh: A randomized study. *Arch Surg* 2004; 139: 1356–1358.
18- Machairas A, Liakakos T, Patapis P, Petropoulos C, Tsapralis D, Misiakos EP: Prosthetic repair of incisional hernia combined with elective bowel operation. *Surgeon* 2008; 6: 274–277.
19- Carbonell AM, Cobb WS: Safety of prosthetic mesh hernia repair in contaminated fields. *Surg Clin North Am* 2013; 93: 1227–1239.
20- Zafar H, Zaidi M, Qadir I, Memon AA.Emergency incisional hernia repair: A difficult problem waiting for a solution. *Ann Surg Innov Res* 2012; 6: 1.
21- Abd Ellatif ME, Negm A, Elmorsy G, Al-Katary M, Yousef Ael-A, Ellaithy R: Feasibility of mesh repair for strangulated abdominal wall hernias. *Int J Surg* 2012; 10: 153–156.
22- Topcu O, Kurt A, Soylu S, Akgol G, Atabey M, Karakus BC, Aydin C: Polypropylene mesh repair of incarcerated and strangulated hernias: A prospective clinical study. *Surg Today* 2013; 43(10): 1140–1144.
23- Sawayama H, Kanemitsu K, Okuma T, Inoue K, Yamamoto K, Baba H. Safety of polypropylene mesh for incarcerated groin and obturator hernias: A retrospective study of 110 patients. *Hernia* 2013 [Epub ahead of print] http://dx.doi.org/10.1007/s10029-013-1058-y.
24- Bessa SS, Abdel-Razek AH: Results of prosthetic mesh repair in the emergency management of the acutely incarcerated and/or strangulated ventral hernias: A seven years study. *Hernia* 2013; 17: 59–65.
25- Iqbal CW, Pham TH, Joseph A, Mai J, Thompson GB, Sarr MG: Long-term outcome of 254 complex incisional hernia repairs using the modified Rives-Stoppa technique. *World J Surg* 2007; 31: 2398–2404.
26- Den Hartog D, Dur AHM, Tuinebreijer WE, Kreis RW: Open surgical procedures for incisional hernias. Cochrane *Database of Systematic Reviews*, 2008, Issue 3. Art. No.: CD006438. DOI: 10.1002/14651858. CD006438.pub2.
27- Tsereteli Z, Pryor BA, Heniford BT, Park A, Voeller G, Ramshaw BJ: Laparoscopic ventral hernia repair (LVHR) in morbidly obese patients. *Hernia* 2007; 12(3): 233–238.
28- Asolati M, Huerta S, Sarosi G, Harmon R, Bell C, Anthony T: Predictors of recurrence in veteran patients with umbilical hernia: Single center experience. *Am J Surg* 2006; 192: 627–630.
29- Rosen MJ, Denoto G, Itani KM, Butler C, Vargo D, Smiell J, Rutan R: Evaluation of surgical outcomes of retro-rectus versus intraperitoneal reinforcement with bio-prosthetic mesh in the repair of contaminated ventral hernias. *Hernia* 2013; 17(1): 31-35.

30- Lin HJ, Spoerke N, Deveney C, Martindale R: Reconstruction of complex abdominal wall hernias using acellular human dermal matrix: A single institution experience. *Am J Surg* 2009;197: 599–603.