Eur J Plast Surg
DOI 10.1007/s00238-014-0961-5

ORIGINAL ARTICLE

Complex incisional hernias repaired in conjunction with the Bony Anchoring Reinforcement System (BARS) prevents hernia recurrence

Andrew I. Elkwood · Frank J. Borao · Russell L. Ashinoff · Matthew R. Kaufman · Michael I. Rose · Amit S. Kharod · Steven J. Binenbaum · John Cece · Tushar R. Patel · Leo R. Otake

Received: 29 January 2014 / Accepted: 12 April 2014

Abstract
Background Complex abdominal wall reconstruction and incisional hernia repair have been plagued by high recurrence rates, especially after multiple repair attempts and in those patients with high body mass index. We present an adjunct technique to validated procedures of hernia repair.
Methods This study is a retrospective analysis of 63 patients between January 2006 and August 2012. Patients had bony suture anchoring of synthetic polypropylene mesh to the anterior superior iliac spine bilaterally, and the pubic symphysis after the abdominal fascia was reconstructed.
Results Patient mean follow-up was 3.1 years (range 6 months to 6 years). None of the 63 patients had recurrent abdominal wall hernias. One patient, from early in the series, had post-operative bulging, which was retreated successfully using the current revised bone anchoring protocol. Five patients developed mesh infections; none of whom required radical debridement or removal of mesh.
Conclusions The BARS technique for abdominal wall reconstruction provides an excellent reinforcement of fascial reconstruction with decreased hernia recurrence rates.
Level of Evidence: Level IV, therapeutic study.

A. I. Elkwood (✉) · R. L. Ashinoff · M. R. Kaufman · M. I. Rose · J. Cece · T. R. Patel · L. R. Otake
The Plastic Surgery Center, The Institute for Advanced Reconstruction, 535 Sycamore Avenue, Shrewsbury, NJ 07702, USA
e-mail: aelkwood@hotmail.com

F. J. Borao · S. J. Binenbaum
10 Industrial Way E, Suite 104, Eatontown, NJ 07724, USA

A. S. Kharod
901 West Main Street, Suite 101, Freehold, NJ 07728, USA

A. I. Elkwood
Surgery Drexel University College of Medicine, Philadelphia, PA, USA

Published online: 18 May 2014

Keywords Hernia · Mesh · Reinforcement · Obesity

Introduction

Complex abdominal wall reconstruction and incisional hernia repair (IHR) have been plagued by high recurrence rates, especially after multiple repair attempts and in those patients with high body mass index (BMI) [1]. Despite the development of numerous surgical techniques and mesh repair, the reported recurrence rate after primary hernia repair ranges from 2 to 25 %, and between 3 and 60 % in those with recurrent repairs [2]. Recent literature has suggested IHR recurrence rates to be less with abdominal component separation [2, 3]. Certain patient factors such as BMI, number of previous recurrences, and integrity of underlying fascia, as well as nutritional status play vital roles in successful abdominal wall reconstruction [1].

We reviewed our experience of 63 patients undergoing the BARS technique to analyze outcomes in an attempt to address the issues described above. The main objective of the present study was to analyze hernia recurrence rates following bony anchoring of synthetic mesh, not as a replacement for hernia repair but rather as a crucial adjunct to abdominal fascial reconstruction.

Material and methods

A total of 63 patients underwent recurrent incisional hernia repair or abdominal wall reconstruction by our group using the BARS technique from January 2006 and August 2012. Within the cohort, 63 % (40/63) patients had undergone previous abdominal wall surgery including hernia repair. The majority

Table 1 Patient demographics

Average age	53.4 (36–71)
Patients	63
Men	17
Women	46
Body mass index	32.3 (21.6–80.9)
Atonic abdominal wall	6
Obese patients (>30 BMI)	41
Morbidly obese patients (>40 BMI)	13
Panniculectomy	31

73 % (46/63) of the patients were women. Patient age ranged from 36 to 71 years with an average of 53 years; overall patient BMI was 32.3 with 13 morbidly obese patients with a BMI >40 including one patient who weighed over 400 lbs and another who had undergone 16 prior abdominal surgeries. Of the cohort, 49 % (31/63) patients underwent concurrent panniculectomy (Table 1).

All patients had bony suture anchoring of synthetic polypropylene mesh (Marlex®; Bard Medical, Covington, GA) to the anterior superior iliac spine (ASIS) bilaterally, and the pubic symphysis after the abdominal fascia was reconstructed (Fig. 1). Patient follow-up was performed at regular time intervals at which time post-surgical complications as well as hernia recurrence rates were recorded. The patients were counseled regarding the repair, biologic and prosthetic material, and the likely post-operative course.

Operative technique

In patients who had a large abdominal pannus, pre-treatment with Diflucan (Pfizer, NY, NY) was used to eradicate yeast colonization. Bowel preparation and nutrition management were addressed pre-operatively, as well as a plan for deep venous thrombosis (DVT) prophylaxis, which sometimes required placement of a vena cava filter. Abdominal exposure was obtained via a lower horizontal incision, a vertical incision, or through a combination horizontal/vertical (i.e., fleur-de-lis) pattern. Previous incisions were used when possible to avoid tissue necrosis between two incisions. An incision was made across the mid-abdomen instead of the abdominal crease to avoid a dependent incision in patients with a large pannus. The umbilicus was sacrificed if deemed non-viable. Foley catheters were inserted in all patients to decompress the bladder, and the patients were placed in Trendelenburg position to better redistribute the abdominal contents as well as the pannus. Exploratory laparotomy and lysis of intra-abdominal adhesions with hernia sac excision was performed prior to fascial closure. Reconstruction of the abdominal fascia was performed with a combination of prosthetic mesh onlay, underlay, or bridging inlay, and in some cases, in conjunction with component separation (Table 2).

A second onlay polypropylene mesh was then tailored to reinforce the entire repair regardless of the method used for fascial closure; this portion of the technique was constant. No sutures were placed in or around the inguinal ligament to prevent injury to the ilioinguinal or genitofemoral nerves. Typically, three bone anchors were used to secure the synthetic mesh at the pubic symphysis and two bone anchors each to the ASIS bilaterally. The superior aspect of the

Fig. 1 Repair of complex recurrent incisional hernias with the bony anchoring reinforcement system (BARS), schematic. Abdominal contents are redirected down into the pelvis as opposed to out in the lower abdomen (*right panel*)

Table 2 Mode of abdominal wall reconstruction or hernia repair

Primary prosthetic onlay	9
Primary biologic onlay	2
Primary prosthetic underlay	2
Imbrication prosthetic onlay	14
Imbrication biologic onlay	1
Component separation biologic onlay	22
Component separation prosthetic onlay	8
Laparoscopic, biologic underlay	2
Laparoscopic, biologic underlay, imbrication	3

prosthetic mesh was sutured to the fascia avoiding any incorporation of the costal perichondrium. Tacking sutures were used to secure the mesh to the rest of the abdominal fascia (Figs. 2 and 3). Post-operative drains were used in all patients.

Results

A total of 63 patients underwent the BARS technique after abdominal wall reconstruction or recurrent incisional hernia repair from January 2006 to August 2012. Patients presented with large W3 (>10 cm) hernias at surgical presentation and exhibited subxyphoid to suprapubic (M1–M5) midline morphology according to the European Hernia Society classification schema [4]. Mean follow-up was 3.1 years with a range from 6 months to 6 years. Overall patient follow-up rate was 100 %. There were no recurrent hernias within the follow-up period in this series. Three patients (5 %) developed a lower extremity DVT in the 30-day post-operative period. These patients were treated with Coumadin (Bristol-Meyers Squibb, NY, NY) to obtain a therapeutic INR. One patient (2 %) developed a bulge of the lower abdomen from fascial laxity 3 months after surgery. The patient was asymptomatic, and no recurrent hernia was evident on clinical exam and was verified by diagnostic imaging. This patient was successfully retreated using the current, more aggressive bone anchoring protocol and has since presented with no progressive morbidity. Mesh-related infection was noted in five patients (8 %), none of whom required radical debridement or total removal of mesh, and which were treated with IV antibiotics. There were no bowel injuries during surgery in any patient. Two patients (3 %) developed nerve-related morbidity in the post-operative period. One patient had lateral femoral cutaneous nerve hypesthesia which resolved spontaneously. The other patient developed an ilioinguinal nerve entrapment from suturing the mesh to the inguinal ligament; this was noted in the post-anesthesia recovery area, and the patient was taken back within 2 h of the procedure to the operating room for nerve release with resolution of symptoms. The technique has now evolved subsequently to avoid the inguinal ligament. Three (5 %) patients developed post-operative abdominal wall seromas, which were serially drained in follow-up. Seven (11 %) patients presented with partial wound dehiscence along the incision lines; morbid obesity (BMI>40) was evident in all seven patients presenting with this wound complication. These patients were treated with a combination of local dressing changes and negative pressure wound vac therapy; two of these patients ultimately required skin grafting to close the wound. Only the solitary patient with an ilioinguinal nerve entrapment described increased, immediate post-operative pain due to the BARS technique. No patients developed osteomyelitis as a consequence of bone anchor placement.

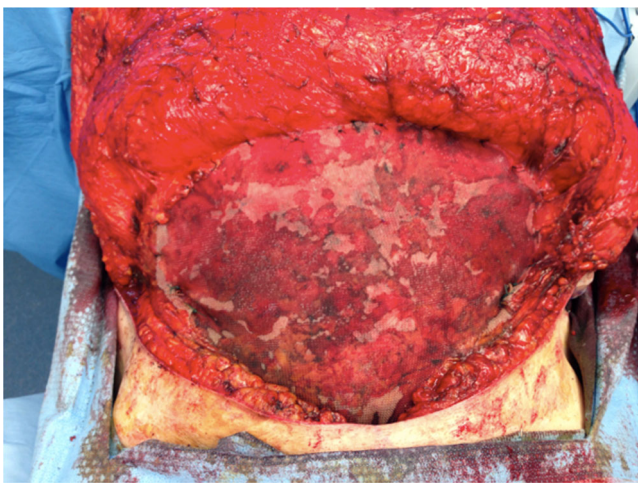

Fig. 2 BARS intra-operative photo. Prosthetic mesh is anchored to the pubic symphysis and bilateral ASIS with bony suture anchors

Discussion

Incisional hernia, one of the most common potentially life-threatening complications of abdominal surgery, occurs in 2–26 % [2] of patients undergoing midline laparotomy and is a vexing surgical complication. Complex abdominal wall reconstruction, especially when recurrent, remains a difficult problem for many reconstructive surgeons. There have been a multitude of options described and practiced to recreate a functional dynamic abdominal wall. Techniques using component separation as described by Ramirez et al. [5], laparoscopic versus open, synthetic versus prosthetic mesh use, as well as mesh inlay versus onlay in recurrent incisional hernia repair have an overall recurrence rate ranging from 3 to 60 % [2] in the literature.

The main finding of this study revealed the use of an adjunct bone-anchored overlay mesh reinforcement system for abdominal wall reconstruction which was associated with significant reduction of abdominal hernia recurrence rates without substantial increase in complications relative to cited literature [1, 2, 5]. This adjunct would be especially valuable

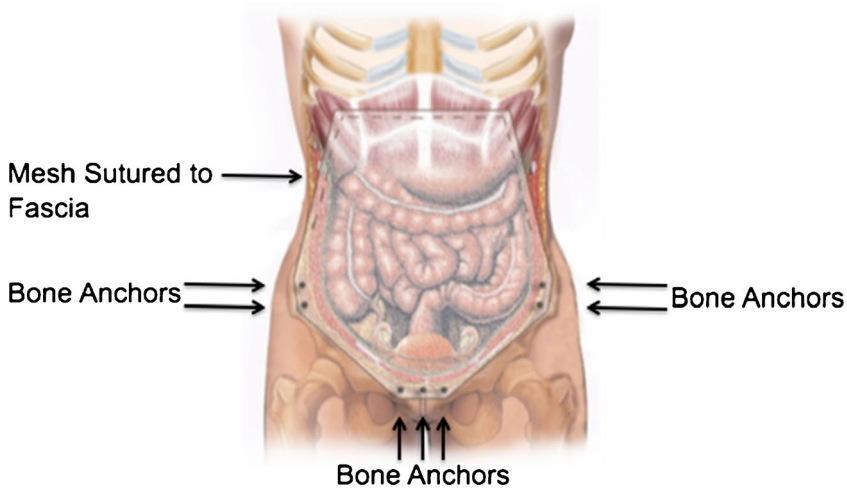

Fig. 3 BARS schematic. Two bone anchors are placed in each anterior superior iliac spine, and two anchors are placed at the pubis. The mesh is secured to the fascia with sutures

for patients with attenuation or atrophy of their abdominal fascia secondary to multiple past surgeries or underlying patient disease; thus, the reinforcement of the abdominal wall via BARS serves as a biologic reinforcing buttress in a sense. In our series of patients, benefit was observed without foreign body reaction to polypropylene mesh, which was well tolerated by our patient population, and without incidence of osteomyelitis secondary to bone anchor placement.

Bowel-related injury remains one of the most important complications during recurrent abdominal hernia repair [6]. Inadvertent intra-operative enterotomies were not observed in our small study. We did note an incidence of wound breakdown and seroma formation (11 and 5 %, respectively) in the study which we primarily attribute to patient obesity which is consistent with reports in the literature [7].

A lower abdominal panniculectomy was performed in many of the patients to assist in operative exposure, to promote reduced tension wound healing, address hygiene issues associated with a pannus, as well as to keep excess weight off of the abdominal wall reconstruction in the post-operative period. Pre-operative Diflucan (Pfizer, NY, NY) for fungal panniculitis was used routinely prior to surgery. Wound breakdown was treated with local wound care and skin grafting where needed. The seromas developed due to large areas of dissection and resolved within 6 months after diagnosis. The BARS technique did not require an extended use of post-operative narcotics.

Concomitant procedures such as panniculectomy speak to the physiologic challenges found in our patient series such as BMI>30, which constituted 41/63 (65 %) of patients, of which 13/41 (32 %) were morbidly obese with BMI>40. In terms of chronological age, our patients averaged 53 years with one patient, a relatively older 71 years. Taken together, these patients would have potentially benefitted from pre-operative bariatric surgery. All obese patients were directed into medically supervised weight loss programs. Despite a persistent potential benefit from bariatric procedures, given the insufficiency of their abdominal wall, they would not have been candidates for laparoscopic approaches with attendant insufflation. The application of BARS could have been a remedy in such a context.

An evolution in practice was appreciated during the course of our study. Initially, a cerclage suture technique was used to anchor the mesh to the pubic symphysis; detractions of this technique included the relatively blind placement of the anchor. Periosteal suturing was also used in our earlier cases for bony anchoring with inconsistent purchase of the periosteum and ultimately less reliable and reproducible results. As described, suturing the mesh to the inguinal ligament resulted in nerve entrapment, and therefore, this technique was abandoned. Edges of the mesh material were folded over to create a smooth contour to reduce the risk of local tissues irritation which may act as a nidus for infection. Anchoring the mesh to the ASIS and pubic symphysis under direct vision with drill holes provides us with the most consistent and reproducible

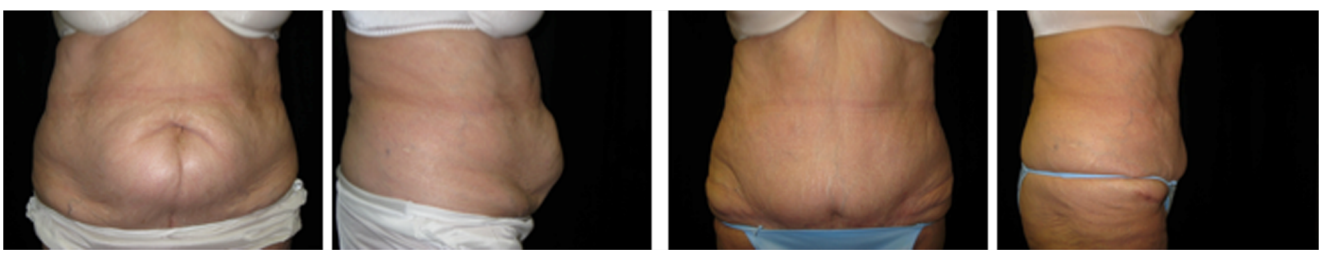

Fig. 4 Pre-operative (*left panel* shows en face and lateral views) and post-operative (*right panel* shows en face and lateral views) images of representative BARS patient

results with the least amount of dissection in the area [8]. The instance of observed abdominal laxity in the study occurred in a patient from the earliest portion of the series; after evolution of the technique as described above, no further hernia recurrences or bulges have been observed. We also recognize that although we did not encounter any such cases in our study, abdominal wall atony and adjacent hernias can occur as a consequence of the component separation technique; thus, reinforcement of the reconstruction with the BARS method precludes what would otherwise be a hernia recurrence in the absence of our technique.

The use of bone anchors as an essential component of hernia repair has been reported in the context of laparoscopic lumbar hernia repair [9], traumatic lumbar hernia repair with anchors in the iliac crest [10], repair of perineal hernia after abdominoperineal resection with anchoring of acellular dermal graft to the pubis [11], and laparoscopic repair of complex ventral hernias with bone anchor placement in the pubic bone or iliac crest [12]. A common theme among these papers is the relative paucity of stable structural element(s) to which a mesh could be secured whether by virtue of anatomy or disruption of anatomy by trauma. As an extension of this logic, the patients in our series presented the same challenges in terms of deranged anatomy as sequelae of intercurrent patient disease states including obesity and attenuated fascia from the trauma of previous multiple surgical interventions; indeed, one of our patients in the series had undergone 16 prior attempted repairs of their ventral hernia. In contrast to the laparoscopic ventral hernia repair with bony anchor fixation where the mesh is placed in an intra-abdominal, inlay, position thus placing the load of abdominal contents onto the mesh [12], the BARS procedure places a stout, bone-anchored mesh as an adjunctive reinforcement to any underlying hernia repair procedure of the surgeon's choice. Such a configuration, we believe, contributes to the durability of BARS in the setting of challenging patient physiology, anatomy, and hernia repair techniques in contrast to the 6.7 % recurrence rate and 3.3 % mortality seen in a series of 30 patients followed for 4 years in the laparoscopic ventral hernia repair paper [12]. The application of bone anchors has facilitated securing of mesh in challenging patients as reported previously [9–13]; BARS extends these works and provides a crucial adjunct to help those patients who, as evidenced by multiple prior surgical interventions, may be considered "unrepairable" by conventional approaches.

We believe that geometry of the abdominal wall plays an important role in recurrence rate. The weight of the intra-abdominal contents should be directed into the pelvis in congruence with its anatomic design, rather than against the surgical repair (Fig. 1). This is especially true when there is a pannus and in patients who have a relatively atonic abdominal wall, the latter being an infrequently discussed complication of multiple abdominal incisions and operations. Decreased physical activity and chronic constipation further may complicate an already problematic abdominal wall.

There are several limitations in our study. This study represents a small sample size retrospective cohort that is not randomized. There is a lack of standardization for indications for abdominal wall reconstruction and IHR as well as fascial repair techniques. This study was not designed to compare standard, well-described techniques of incisional hernia repair to our bony suture anchoring (BARS) method. Instead, our goal is to provide preliminary data, which attempts to substantiate an adjunct reinforcement system to the standard techniques of abdominal wall reconstruction and therefore illustrate redirecting of abdominal contents, resulting in an absolute reduction of hernia recurrence. Ideally, long-term prospective studies are needed to provide multivariate data. A previous series of seven hernia patients who were repaired with a bone-anchored mesh technique cited the need for larger patient series [14]; indeed, our larger survey of 63 patients extends this theme and encompasses many different modalities of hernia repair which are rendered more effective as a direct consequence of incorporating the BARS procedure.

Conclusion

Our technique provides a versatile method of reinforcing the reconstructed abdominal wall. A dynamic repair of the fascia is obtained with or without using standard prosthetic mesh and is further reinforced. Although this repair is subject to the variability in inspiration/expiration, fluctuations in intra-abdominal pressures from lifting and relaxing, as well as the inherent weakness of the infra-arcuate abdominal wall, our approach redirects the vector of abdominal wall stresses into the pelvis. Intra-abdominal contents are redirected down into the pelvis as opposed to against the lower abdominal wall. We describe a technique with the use of a large synthetic mesh suture anchored to bony fixation points (ASIS/pubic symphysis) in conjunction with validated hernia repair techniques to reduce abdominal hernia recurrence while providing an aesthetically superior abdominal wall contour (Fig. 4).

Conflict of Interest None

Ethical standards The study has been approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. All persons gave their informed consent prior to their inclusion in the study.

References

1. Hawn MT, Snyder CW, Graham LA, Gray SH, Finan KR, Vick CC (2010) Long-term follow-up of technical outcomes for incisional hernia repair. J Am Coll Surg 210:648–656
2. Bisgaard T, Kehlet H, Bay-Nielsen MB et al (2009) Nationwide study of early outcomes after incisional hernia repair. Br J Surg 96: 1452–1457
3. Tong WM, Hope W, Overby DW, Hultman CS (2011) Comparison of outcome after mesh-only repair, laparoscopic component separation, and open component separation. Ann Plast Surg 66:551–556
4. Muysoms FE, Miserez M, Berrevoet F, Campanelli G et al (2009) Classification of primary and incisional abdominal wall hernias. Hernia 13:407–414
5. Ramirez OM, Ruas E, Dellon AL (1990) Components separation method for closure of abdominal-wall defects: an anatomic and clinical study. Plast Reconstr Surg 83:519–526
6. Misra MC, Bansal VK, Kulkarni MP, Pawar DK (2006) Comparison of laparoscopic and open repair of incisional and primary ventral hernia: results of a prospective randomized study. Surg Endosc 20: 1839–1845
7. Sorensen LT, Hemmingsen UB, Kirkeby LT, Kallehave F, Jurgensen LN (2005) Smoking is a risk factor for incisional hernia. Arch Surg 140:119–123
8. Sisco M, Dumanian GA (2005) A simple technique to anchor prosthetic mesh to bone. Plast Reconstr Surg 116:2059–2060
9. Ho VP, Dakin GF (2011) Laparoscopic lumbar hernia repair with bone anchor fixation. Surg Endosc 25:1665
10. Links DJR, Berney CR (2011) Traumatic lumbar hernia repair: a laparoscopic technique for mesh fixation with an iliac crest suture anchor. Hernia 15:691–693
11. Kathju S, Lasko L, Medich DS (2011) Perineal hernia repair with acellular dermal graft and suture anchor fixation. Hernia 15:357–360
12. Yee JA, Harold KL, Cobb WS, Carbonell AM (2008) Bone anchor mesh fixation for complex laparoscopic ventral hernia repair. Surg Innov 15:292–296
13. Sun R, Choi K, Coots B (2013) The use of the Mitek anchoring system on the iliac crest for flank incisional hernia repair. Eur J Plast Surg 36:335–338
14. Ali A, Malata CM (2012) Use of Mitek bone anchors for synthetic mesh fixation to repair recalcitrant abdominal hernias. Ann Plast Surg 69:59–63