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ORIGINAL ARTICLE

Rectus abdominis atrophy after ventral abdominal incisions: midline versus chevron

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Abstract

Purpose Although many outcomes have been compared between a midline and chevron incision, this is the first study to examine rectus abdominis atrophy after these two types of incisions.

Methods Patients undergoing open pancreaticobiliary surgery between 2007 and 2011 at our single institution were included in this study. Rectus abdominis muscle thickness was measured on both preoperative and follow-up computed tomography (CT) scans to calculate percent atrophy of the muscle after surgery.

Results At average follow-up of 24.5 and 19.0 months, respectively, rectus abdominis atrophy was 18.9% greater in the chevron ($n = 30$) than in the midline ($n = 180$) group (21.8 vs. 2.9%, $p < 0.0001$). Half the patients with a chevron incision had >20% atrophy at follow-up compared with 10% with a midline incision [odds ratio (OR) 9.0, $p < 0.0001$]. No significant difference was observed in incisional hernia rates or wound infections between groups.

Conclusion In this study, chevron incisions resulted in seven times more atrophy of the rectus abdominis compared with midline incisions. The long-term effects of transecting the rectus abdominis and disrupting its innervation creates challenging abdominal wall pathology. Atrophy of the abdominal wall can not be readily fixed with an operation, and this significant side effect of a transverse incision should be factored into the surgeon's decision-making process when choosing a transverse over a midline incision.

Keywords Chevron incision · Rectus atrophy · Midline versus transverse incision · Laparotomy incisions

Introduction

Despite the widespread use of laparoscopy for most gastrointestinal surgery, laparotomy is still frequently required and performed. Laparotomy can be performed via several different incision types, and although most surgeons prefer either a midline or transverse incision (chevron or subcostal), there is no universally agreed-upon best incision. Thus, incisions are often chosen based on limited retrospective data, surgeon preference, and consideration of patient factors, such as exposure required and patient body habitus. Long debate over these two types of incisions have led to investigation of differences in postoperative pain, respiratory function, incidence of hernia formation, and wound-healing complications [1–4]. Yet, despite all these considerations, postoperative abdominal wall muscle strength and function has not been studied and is rarely considered in this decision-making process.

We anecdotally found several patients return to clinic years after a chevron incision for hernia evaluation. On exam, they had no hernia but in fact had abdominal wall weakness and deformity secondary to muscle atrophy. Chevron incisions, by nature, involve greater manipulation and trauma to the rectus abdominis compared with the midline incision through the linea alba. Thus, given our clinical experience, we hypothesized that rectus abdominis muscle atrophy would be greater after an operation through a chevron than a midline incision.

In order to study long-term rectus atrophy, we used perioperative computed tomography (CT), which alone revealed to a blinded radiologist whether a patient has had

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a prior operation based on muscle atrophy seen on images [5]. In fact, in 2003, rectus abdominis muscle atrophy was studied after infrarenal aortic repair. On perioperative CT imaging, patients with a paramedian incision demonstrated significantly more rectus abdominis atrophy than those in whom a flank incision was used [6]. We similarly used CT imaging to study rectus abdominis atrophy in our gastrointestinal surgery patients after a midline or chevron incision to test our hypothesis.

Methods

Between 2007 and 2011, 338 patients at our institution underwent an open pancreatic operation using either a chevron or midline incision based on surgeon preference. Due to the nature of the pathology, most patients had perioperative imaging available, and our retrospective review was approved by the Institutional Review Board at NorthShore University HealthSystem. Patients had accessible preoperative CT scans and follow-up scans >1 month after surgery. Patients with imaging prior to 1 month were excluded due to expected immediate postoperative inflammation and edema, resulting in insufficient time and reduced ability to identify atrophy.

All patients were identified by age, gender, and body mass index (BMI), along with other potential factors impacting wound healing and atrophy: smoking history, comorbidities, preoperative albumin, diagnosis, postoperative complications, and the use of adjuvant therapies such as chemotherapy and radiation.

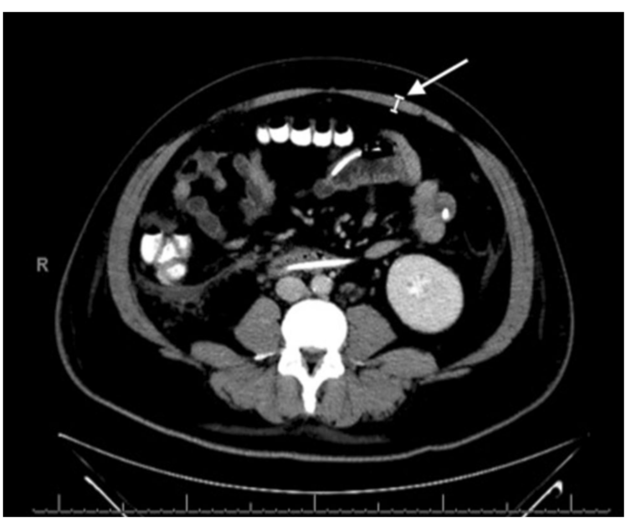

Fig. 1 Example CT with sample rectus abdominis width measurement denoted by the *arrow*

To ensure internal data consistency, a single blinded reviewer using the same imaging software performed all measurements. The left-sided rectus abdominis muscle was measured at its median width on the axial CT image at the L3 vertebral body level (Fig. 1) from the preoperative CT scan and the most distant postoperative scan. The difference in muscle thickness was calculated as a percentage of muscle atrophy. Muscle thickness on preoperative scans was considered 100%. Change in muscle thickness was calculated as below:

$$(\text{preop} - \text{postop})/(\text{preop}) \times 100\% = \text{percent atrophy}.$$

Secondary endpoints included incisional hernias reported on CT radiology interpretations and wound infections identified during admission or at follow-up. The categorical variables were analyzed using chi-square test, and additional numerical data was analyzed using Student's t test.

Results

Two hundred and ten of the 338 patients in the database met inclusion criteria; 180 of them were operated through a midline incision and 30 through a chevron incision. Both groups shared similar demographics, with no significant difference in BMI, gender, or smoking between groups (Table 1). However, the midline group was about 5 years younger than the chevron group (64.5 vs 69.8, $p = 0.03$).

There was 18.9% rectus abdominis atrophy in the chevron than the midline group (21.8% vs. 2.9%, $p < 0.0001$). Additionally, 77.3% (22/30) of the chevron group had >10% atrophy at follow-up compared with 24.4% (44/180) of the midline group [odds ratio (OR) 8.5, $p < 0.0001$); 50% (15/30) of the chevron group had >20% atrophy compared with 10% (18/180) of the midline group (OR 9.0, $p < 0.0001$). Atrophy was evaluated at an average follow-up of 24.5 and 19.0 months, respectively ($p = 0.07$), as seen in Table 2. Additionally, no significant difference was observed in incisional hernia rates or wound infections between groups.

Table 1 Patient characteristics

	Midline ($n = 180$)	Chevron ($n = 30$)	P value
Age (years)	64.5	69.8	0.03
Sex			
Male (%)	90 (50.0%)	15 (50%)	1
Female (%)	90 (50.0%)	15 (50%)	
Body mass index	26.3 ± 0.4	26.8 ± 1.3	0.66
Smokers	98 (55.4%)	13 (43.3%)	0.23

Table 2 Midline vs chevron incision outcomes

	Midline ($n = 180$)	Chevron ($n = 30$)	P value
Months to follow-up	19.0 ± 1.1	24.5 ± 3.3	0.07
Percent atrophy	2.90% ± 1.1	21.8% ± 3.9	<0.0001[a]
Incisional hernias	15 (8.33%)	2 (6.67%)	0.76
Wound infection	43 (23.9%)	11 (36.7%)	0.14

[a] $p = 1.58\text{E}{-08}$

Table 3 Potetial variables impacting atrophy

	Midline ($n = 180$)	Chevron ($n = 30$)	P value
Preoperative albumin	3.55 ± 0.92	3.40 ± 2.14	0.22
ASA			
1	1 (0.6%)	0 (0%)	0.57
2	76 (42.2%)	11 (36.7%)	
3	96 (53.3%)	19 (63.3%)	
4	7 (3.9%)	0 (0%)	
Comorbidities			
Diabetes mellitus	42 (23.3%)	5 (16.7%)	0.5
Cardiovascular disease	36 (20.0%)	7 (23.3%)	0.6
Diagnosis			
Malignant	146 (81.1%)	18 (60.0%)	0.01
Benign	34 (18.9%)	12 (40.0%)	
Operation			
Whipple/total pancreatic	128 (70.0%)	18 (60.0%)	0.22
Other pancreatic	52 (30.0%)	12 (40.0%)	
Additional therapy			
Chemotherapy			
Neoadjuvant	8 (4.5%)	0 (0%)	0.24
Adjuvant	76 (42.5%)	10 (33.3%)	0.36
Radiation	39 (21.8%)	5 (16.7%)	0.53

Other potential factors thought to impact atrophy are listed in Table 3. The midline group had 21% more malignant cases ($p = 0.01$). Preoperative albumin, American Society of Anesthesiologists (ASA) score, comorbidities, smoking history, and adjuvant chemotherapy demonstrated no significant differences.

Discussion

This is the first study to investigate and quantify the amount of rectus abdominis atrophy after laparotomy. We demonstrate a large difference in postoperative atrophy between transverse chevron and midline incisions. In fact, patients with chevron incisions were nine times more likely to have >20% atrophy than those with midline incisions; on average, chevron incisions resulted in 19% more atrophy. Our findings correlate with our clinical experience and long-term follow-up of these patients. Often, patients with a chevron incision present to clinic for evaluation of a hernia; however, the pathology of their abdominal wall is solely atrophy, the etiology of of which is likely twofold. First, muscle loss occurs due to physical transection and remodeling of muscle fibers. Second, and more importantly, direct trauma or transection of the intercostal nerves when opening the abdominal wall layers leads to denervation and subsequent muscle atrophy. Management of patients with symptomatic abdominal wall atrophy is challenging, as they cannot be treated with an operation; thus, as surgeons, the best measures we can often offer are supportive only.

Long-term abdominal wall atrophy has not largely been a factor when choosing the type of laparotomy incision. In fact, in the fields of general and oncologic surgery, the optimal laparotomy incision has never been agreed upon. Over the years, many researchers have studied the clinical impact of these two incisions with regard to postoperative infections, hernias, and analgesia requirements [2, 3]. Yet, the most recent Cochrane Review concluded that recovery and complication rates were similar regardless of incision type. The only observable difference was that the transverse approach affected pulmonary function less, yet it did not result in any differences in clinical outcome [7]. Thus, because neither incision has demonstrated superiority, the choice of incision is often based on personal surgeon preference with consideration of patient/operation-specific factors. The foremost consideration is which incision allows for appropriate visualization and a safe operation. However, if incisions are otherwise equivalent, we believe the preferred incision should be midline, given our findings here and the tremendous increased risk of long-term atrophy after a transverse incision.

This study is limited in that we could not study clinical implications of the resulting atrophy. However, we believe postoperative atrophy likely influences patient satisfaction and abdominal wall function. Similar effects of abdominal wall weakness and abdominal bulge is a significant complication seen by breast and plastic surgeons during autologous tissue reconstructive procedures. Even when muscle-sparing techniques are used to conserve part of the rectus abdominis muscle, the remaining muscle proceeds to atrophy in as early as 2 months due to denervation during the operation [8, 9]. Clinical outcomes reported after such atrophy include both visual deformities of the abdominal wall on exam and patient complaints of difficulty lifting objects and doing situps [10].

Postoperative rectus abdominis atrophy may be an overlooked factor in general surgery, and through this study we demonstrate that a significant amount of atrophy will result after a transverse incision. Rectus atrophy could be associated with important patient morbidity, which should be explored with prospective studies of abdominal wall function and quality of life after different incisions. However, given our initial results reported here, we believe rectus atrophy is an important consequence and should be included in the surgeon's decision-making process when choosing between an upper midline versus a transverse incision for open surgery.

Compliance with ethical standards

Conflict of interest YV, EP, MT, SH, JL and MU declare no conflict of interest. All authors YV, EP, MT, SH, JL and MU contributed to the preparation and review of the manuscript. MT, SH, JL and MU contributed to conception and design of the study. EP and YV contributed to data collection and analysis.

Ethical approval For this type of study formal consent is not required.

Human and animal rights All procedures performed in studies involving human participants were in accordance with ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained for all individual participants included in the study.

References

1. Bucknall TE, Cox PJ, Ellis H (1982) Burst abdomen and incisional hernia: a prospective study of 1129 major laparotomies. Br Med J (Clin Res Ed) 284(6320):931–933
2. Greenall MJ, Evans M, Pollock AV (1980) Midline or transverse laparotomy? A random controlled clinical trial. Part I: influence on healing. Br J Surg 67(3):188–190
3. Halm JA, Lip H, Schmitz PI, Jeekel J (2009) Incisional hernia after upper abdominal surgery: a randomised controlled trial of midline versus transverse incision. Hernia 13(3):275–280
4. Seiler CM, Deckert A, Diener MK, Knaebel HP, Weigand MA, Victor N et al (2009) Midline versus transverse incision in major abdominal surgery: a randomized, double-blind equivalence trial (POVATI: ISRCTN60734227). Ann Surg 249(6):913–920
5. Goodman P, Balachandran S (1991) Postoperative atrophy of abdominal wall musculature: CT demonstration. J Comput Assist Tomogr 15(6):989–993
6. Yamada M, Maruta K, Shiojiri Y, Takeuchi S, Matsuo Y, Takaba T (2003) Atrophy of the abdominal wall muscles after extraperitoneal approach to the aorta. J Vasc Surg 38(2):346–353
7. Brown SR, Goodfellow PB (2005) Transverse verses midline incisions for abdominal surgery. Cochrane Database Syst Rev 2005(4):CD005199
8. Duchateau J, Declety A, Lejour M (1988) Innervation of the rectus abdominis muscle: implications for rectus flaps. Plast Reconstr Surg 82(2):223–228
9. Tønseth KA, Günther A, Brabrand K, Fogdestam I, Hokland BM (2005) Ultrasonographic evaluation of the rectus abdominis muscle after breast reconstruction with the DIEP flap. Ann Plast Surg 54(5):483–486
10. Atisha D, Alderman AK (2009) A systematic review of abdominal wall function following abdominal flaps for postmastectomy breast reconstruction. Ann Plast Surg 63(2):222–230