

# Risk Factors for Incisional Hernia After Open Abdominal Aortic Aneurysm Repair

TAKASHI ENDO, KAZUHIRO MIYAHARA, TAKURO SHIRASU, YASUAKI MOCHIZUKI,  
RYOSUKE TANIGUCHI, TOSHIO TAKAYAMA and KATSUYUKI HOSHINA

*Division of Vascular Surgery, Department of Surgery,  
Graduate School of Medicine, The University of Tokyo, Tokyo, Japan*

**Abstract.** *Background/Aim: Incisional hernia is among the most prevalent complications associated with open abdominal aortic aneurysm repair. However, risk factors for incisional hernias in patients with abdominal aortic aneurysm are multifactorial. Therefore, this study evaluated the risk factors of incisional hernia after open abdominal aortic aneurysm repair, including surgical factors. Patients and Methods: We retrospectively extracted data from patients with incisional hernias after abdominal aortic aneurysm repair between 2012 and 2019 and investigated their perioperative characteristics and wound closure techniques. Results: The mean follow-up periods were  $41.5 \pm 30.3$  months, and 30 of 131 (22.9%) patients suffered an incisional hernia. Regarding the underlying disease, only diabetes mellitus was significantly more common in the incisional hernia group (11 of 30 patients, 36.6%), and no significant differences were found in the patients' perioperative data. Interrupted sutures were used in all 30 patients in the hernia group. Moreover, in 8 of the 101 remaining cases, barbed sutures were used, and no incisional hernia occurred in any of these cases. Conclusion: In addition to diabetes mellitus, abdominal aortic aneurysm is a significant risk factor for incisional hernia after abdominal aortic aneurysm repair. Therefore, employing the barbed suture technique may effectively prevent incisional hernias after abdominal aortic aneurysm repair.*

*Correspondence to:* Katsuyuki Hoshina, Division of Vascular Surgery, Department of Surgery, Graduate School of Medicine, the University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8655, Japan. Tel: +81 338155411, Fax: +81 338116822, e-mail: traruba@gmail.com

*Key Words:* Incisional hernia, open AAA repair, risk factors.

Over the past two decades, abdominal aortic aneurysm (AAA) surgery has significantly changed, with many surgeons opting for endovascular aortic repairs (EVAR) over open surgeries. However, open surgery remains a crucial option owing to its superior cost-effectiveness and long-term prognosis. Despite these advantages, one of the most prevalent complications of open AAA repair is incisional hernias. In retrospective studies, the incidence of this complication has been reported to be as high as 37% (1), with >80% of patients experiencing related symptoms (2, 3). These symptoms include chronic abdominal pain and discomfort and can lead to severe complications, such as intestinal strangulation, bowel obstruction, and perforation. Additionally, patients with incisional hernias have been found to have a significantly lower health-related quality of life and body image than those without hernias (3).

Moreover, AAA has been reported to be an independent risk factor for incisional hernia after laparotomy (4, 5). Patients with aneurysms are known to have potential defects in collagen and elastin production (6, 7), suggesting that connective tissue abnormalities may affect wound healing, predisposing patients to incisional hernia following AAA repair.

Several studies have reported the risk of incisional hernia, which can be classified into patient-related factors, such as obesity and surgery-related factors. While many have reported patient-related factors, there are few reports on surgical factors in patients with AAAs (8, 9).

Therefore, this study aimed to analyze the risk factors for incisional hernia after open AAA repair, including surgical factors, and explore potential measures, such as a unique continuous suture system for abdominal closure that vascular surgeons can adopt to mitigate these risks.

## Patients and Methods

Between January 2012 and December 2019, 131 patients underwent open AAA repair at the Department of Vascular Surgery at the University of Tokyo. Notably, patients who did not undergo a midline



This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY-NC-ND) 4.0 international license (<https://creativecommons.org/licenses/by-nc-nd/4.0/>).

abdominal incision (e.g., a transverse incision or retroperitoneal approach) were excluded from this study. However, emergency surgical cases were included in this study. We retrospectively analyzed the patients' clinical records and telephone surveys. Written informed consent was obtained from all patients prior to their participation in the study. This study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the University of Tokyo Hospital [no. 3316-(4)].

The recorded baseline characteristics were age, sex, body mass index, smoking history, history of cardiovascular disease, hypertension, diabetes, dyslipidemia, dialysis, chronic obstructive pulmonary disease, and laparotomy. Incisional hernia was diagnosed based on clinical findings or computed tomography findings. However, in cases where symptoms, such as abdominal distension or abdominal discomfort were observed, the diagnosis was made when a hernial orifice was identified during examination by a surgeon and even in asymptomatic cases, when there were findings of the peritoneum touching the abdominal wall on a postoperative follow-up computed tomography scan. Perioperative data included preoperative hemoglobin and albumin levels, psoas muscle index to measure sarcopenia, operative time and blood loss, and postoperative hospital stay as evaluation criteria. The psoas muscle index was calculated using a previously reported method (10). The cut-off values for sarcopenia were defined as a psoas muscle index of 6.36 cm<sup>2</sup>/m<sup>2</sup> for males and 3.92 cm<sup>2</sup>/m<sup>2</sup> for females. Regarding surgical techniques, we focused on the method of wound closure and categorized them as interrupted or continuous sutures using STRATAFIX Symmetric PDS Plus (ETHICON Inc., Cincinnati, OH, USA).

The volume of the bilateral psoas muscle was calculated using Horos 3.3.5, an open-source medical image viewer. All data were statistically analyzed using JMP Pro 15 software (SAS Institute Inc. Cary, NC, USA). Continuous variables are presented as means±standard deviations, and categorical variables are presented as numbers and percentages. Each category was analyzed by *t*-test or  $\chi$ -square test. For each analysis, a *p*-value <0.05 was considered statistically significant.

## Results

Patient characteristics are shown in Table I. The mean follow-up periods were 41.5±30.3 months, and 30 of 131 (22.9%) patients had incisional hernias. No statistically significant differences were noted in age, sex, body mass index, or smoking history between the two groups (*i.e.*, the hernia and non-hernia groups). Approximately 30% of the patients had a history of laparotomy; however, no significant differences were found between the groups. Regarding the underlying disease, only diabetes mellitus was significantly more common in the incisional hernia group (11 of 30 patients, 36.6%).

The mean time to diagnosis was 17.2±16.1 months. Of the 30 patients with incisional hernias, only two patients underwent hernia repair surgery: one patient had severe abdominal discomfort and pain due to the hernia and requested surgery, and one patient underwent hernia repair at the same time as laparotomy for another disease. No intestinal strangulation, bowel obstruction, or perforation occurred during the follow-up.

Although each group included emergency cases, no significant differences were observed in operative time, blood loss, or postoperative hospital stay between the two groups (Table II). In addition, preoperative hemoglobin and albumin levels in both groups were within normal limits and did not differ significantly. Furthermore, although the mean body mass index was within normal limits in both groups, approximately 20% of the patients had sarcopenia, which was also not statistically significant (*p*=0.614).

The methods used for abdominal wall closure are listed in Table III. Interrupted sutures were used in all 30 patients in the hernia group. In contrast, in the non-hernia group, continuous sutures were used in 8 of the 101 patients. We introduced continuous suture closure of the abdominal wall using STRATAFIX, an anchored absorbable monofilament suture. From the observed data, there were no cases of incisional hernia in patients with continuous sutures; therefore, a significant difference was found between the two groups (*p*=0.0387).

## Discussion

Previous studies have reported the risk factors associated with incisional hernia in patients with AAAs. The exact pathophysiology of an incisional hernia in open AAA repair is likely multifactorial, with patient- and surgery-related risk factors falling into this classification (11). Although increased age, obesity, and prior laparotomy are patient-related risk factors for incisional hernia following open surgery (8, 9), these factors did not exhibit any significant differences between the groups in this study. Further, chronic obstructive pulmonary disease is another significant risk factor for wound dehiscence (12, 13); however, we found no relatable differences between the two groups in this study. Furthermore, Van Rooijen *et al.* have revealed that sarcopenia is not a risk factor for incisional hernia (14), and consistent with this finding, we did not find any differences between the two groups.

Regarding the underlying disease, the association between autosomal dominant polycystic kidney disease and abdominal incisional herniation is well-known; particularly, Morris-Stiff have reported that 45% of autosomal dominant polycystic kidney disease patients had an incisional hernia (15). Although there were no patients with autosomal dominant polycystic kidney disease in the two groups in this study, the potential fragility of the abdominal wall due to errors in collagen metabolism may contribute to incisional hernia and should be carefully considered during surgery for patients with this background disease.

Among the factors included in our study, diabetes mellitus was more frequently observed in the incisional hernia group. Although most diabetic patients in our investigation had well-controlled blood glucose levels before and after surgery, most incisional hernias occurred more than one year after surgery. One possible explanation for this disparity is the

Table I. Patient characteristics.

	Incisional hernia (n=30)	None (n=101)	<i>p</i> -Value
Age	70.7±8.9	71.0±8.8	0.848
Sex (male/female)	23:7 (76.6%)	90:11 (89.1%)	0.082
BMI	24.5±3.6	23.5±3.4	0.133
Smoking	22 (73.3%)	78 (77.2%)	0.660
Cardiovascular disease	9 (30.0%)	26 (25.7%)	0.644
Hypertension	25 (83.3%)	70 (69.3%)	0.131
Dyslipidemia	18 (60.0%)	57 (56.4%)	0.729
Diabetes	11 (36.6%)	15 (14.8%)	<b>0.009</b>
Renal dysfunction (Dialysis)	0 (0.00%)	3 (2.97%)	0.340
COPD	13 (43.3%)	44 (43.6%)	0.982
History of laparotomy	9 (30.0%)	33 (32.6%)	0.783

COPD: Chronic obstructive pulmonary disease. Significant *p*-values are shown in bold.

Table II. Perioperative characteristics.

	Incisional hernia (n=30)	None (n=101)	<i>p</i> -Value
Preoperative			
Hb (g/dl)	13.8±1.9	13.1±2.8	0.132
Alb (g/dl)	3.9±0.3	3.8±0.5	0.069
PMI (cm <sup>2</sup> /m <sup>2</sup> )	7.00±1.9	7.17±1.7	0.665
Male	7.55±1.7	7.41±1.6	0.740
Female	5.19±1.1	5.17±1.0	0.980
Sarcopenia (male/female)	5 (16.7%) 5:0	23 (22.8%) 21:2	0.614
Emergency surgery	1 (3.33%)	7 (6.93%)	0.470
Operation time (min)	279±74	286±250	0.792
Blood loss (ml)	1486±836	1296±832	0.137
Postoperative hospital stay (day)	15.4±7.4	14.7±7.8	0.707

Hb: Hemoglobin; Alb: albumin; PMI: psoas muscle index.

Table III. Suturing method for the abdominal wall.

	Incisional hernia (n=30)	None (n=101)	<i>p</i> -Value
Suture technique			
Interrupted	30	93	0.0378
Continuous (Barbed)	0	8	

compromised wound-healing characteristics of diabetes, and this finding was consistent with similar results reported in previous studies (16).

Typically, incisional hernias manifest within one year after surgery. However, most incisional hernia cases in this study occurred at least one year after surgery. A previous study in our country has reported that nearly 50% of patients who underwent open surgery experienced incisional hernias within 6 months, whereas 64% experienced such hernias

within one year (17). In our study, only 8 of the 30 patients (26.7%) had an incisional hernia within 6 months of surgery, indicating that incisional hernias are more likely to occur in later periods, particularly in patients with AAA. This suggests that collagen weakening, which is caused by the AAA itself, may be the primary contributing factor to incisional hernia, as opposed to surgery-related factors. Thus, this supports previous research findings indicating that AAA is an independent risk factor for incisional hernia (4, 5).

Furthermore, in this study, several patients experienced early incisional hernias after primary surgery. Within a month, 2 of the 30 patients in the hernia group developed an incisional hernia. Therefore, we considered that the underlying cause of these cases is more possibly surgery-related rather than patient-related. Among surgery-related factors, suture techniques after laparotomy play a critical role in the incidence of incisional hernia. Israelsson *et al.* have shown that a high suture length-to-wound length ratio of at least 4:1 significantly reduces the incidence of incisional hernias in midline laparotomy wounds (18). Similarly, a multicenter randomized controlled trial from the Netherlands has revealed that small bites with a running suture technique were more effective in preventing incisional hernia than the large bite technique and were not associated with increased pain or adverse events (19).

In our study, all patients were sutured using roof-tile-style techniques within the same department under the constant supervision of the attending surgeons. In particular, all patients with an incisional hernia underwent the interrupted suture technique, and none of the patients who underwent the barbed suture technique developed an incisional hernia. This result may be attributed to the fact that the interrupted sutures could not maintain the high suture length to wound length. In addition, compared to conventional interrupted sutures or running sutures, both of which create high tension at the point of insertion, barbed sutures are highly advantageous because the tissue is much less likely to tear (20). Therefore, barbed sutures could be an effective technique for preventing incisional hernias that surgeons can easily introduce.

This study had several limitations. First, this was a retrospective, single-center study. Second, the number of cases may be too small to analyze multiple factors in this study. Third, the choice of suture and suture technique was at the attending surgeon's discretion. Fourth, because of the small number of cases and the wide variety of suture procedures, our results cannot be generalized to other methods of abdominal closure. Therefore, additional studies are warranted to examine more cases and provide more robust evidence for the prevention of incisional hernias after open AAA repair.

## Conclusion

Diabetes mellitus is a risk factor for incisional hernias after AAA repair. In addition, late incisional hernias occur in patients with AAA, suggesting that the AAA itself may also be a significant risk factor. Therefore, utilizing the barbed suture technique may be an effective method for preventing incisional hernias following AAA repair.

## Conflicts of Interest

The Authors have no conflicts of interest to declare in relation to this study.

## Authors' Contributions

Study conception: TE; Data collection: TE; Analysis: TE; Investigation: TE; Writing: TE; Critical review and revision: all Authors; Final approval of the article: all Authors; Accountability for all aspects of the work: all Authors.

## Acknowledgements

The Authors would like to thank Editage (www.editage.com) for English language editing.

## Funding

The research received no specific grants from any funding agency in the public, commercial, or non-for-profit sectors.

## References

- Raffetto JD, Cheung Y, Fisher JB, Cantelmo NL, Watkins MT, Lamorte WW, Menzoian JO: Incision and abdominal wall hernias in patients with aneurysm or occlusive aortic disease. *J Vasc Surg* 37(6): 1150-1154, 2003. DOI: 10.1016/s0741-5214(03)00147-2
- Holland A, Castleden W, Norman P, Stacey M: Incisional hernias are more common in aneurysmal arterial disease. *Eur J Vasc Endovasc Surg* 12(2): 196-200, 1996. DOI: 10.1016/s1078-5884(96)80106-7
- Van Ramshorst GH, Eker HH, Hop WC, Jeekel J, Lange JF: Impact of incisional hernia on health-related quality of life and body image: a prospective cohort study. *Am J Surg* 204(2): 144-150, 2012. DOI: 10.1016/j.amjsurg.2012.01.012
- Takagi H, Sugimoto M, Kato T, Matsuno Y, Umemoto T: Postoperative incision hernia in patients with abdominal aortic aneurysm and aortoiliac occlusive disease: a systematic review. *Eur J Vasc Endovasc Surg* 33(2): 177-181, 2007. DOI: 10.1016/j.ejvs.2006.07.009
- Henriksen NA, Helgstrand F, Vogt KC, Jorgensen LN, Bisgaard T: Risk factors for incisional hernia repair after aortic reconstructive surgery in a nationwide study. *J Vasc Surg* 57(6): 1524-1530.e3, 2013. DOI: 10.1016/j.jvs.2012.11.119
- Urabe G, Hoshina K, Shimanuki T, Nishimori Y, Miyata T, Deguchi J: Structural analysis of adventitial collagen to feature aging and aneurysm formation in human aorta. *J Vasc Surg* 63(5): 1341-1350, 2016. DOI: 10.1016/j.jvs.2014.12.057
- Van Der Vliet JA, Boll APM: Abdominal aortic aneurysm. *Lancet* 349(9055): 863-866, 1997. DOI: 10.1016/s0140-6736(96)07282-0
- Itatsu K, Yokoyama Y, Sugawara G, Kubota H, Tojima Y, Kurumiya Y, Kono H, Yamamoto H, Ando M, Nagino M: Incidence of and risk factors for incisional hernia after abdominal surgery. *Br J Surg* 101(11): 1439-1447, 2014. DOI: 10.1002/bjs.9600
- Fischer JP, Basta MN, Mirzabeigi MN, Bauder AR, Fox JP, Drebin JA, Serletti JM, Kovach SJ: A risk model and cost analysis of incisional hernia after elective, abdominal surgery based upon 12,373 cases: the case for targeted prophylactic intervention. *Ann Surg* 263(5): 1010-1017, 2016. DOI: 10.1097/SLA.0000000000001394

- 10 Hamaguchi Y, Kaido T, Okumura S, Kobayashi A, Hammad A, Tamai Y, Inagaki N, Uemoto S: Proposal for new diagnostic criteria for low skeletal muscle mass based on computed tomography imaging in Asian adults. *Nutrition* 32(11-12): 1200-1205, 2016. DOI: 10.1016/j.nut.2016.04.003
- 11 Nguyen T-M, Rajendran S, Brown KGM, Saha P, Qasabian R: Incisional hernia following open abdominal aortic aneurysm repair: A contemporary review of risk factors and prevention. *Vasc Endovasc Rev* 3: e01, 2020.
- 12 Besancenot A, Salomon Du Mont L, Lejay A, Heranney J, Delay C, Chakfé N, Rinckenbach S, Thaveau F: Risk factors of long-term incisional hernia after open surgery for abdominal aortic aneurysm: a bicentric study. *Ann Vasc Surg* 83: 62-69, 2022. DOI: 10.1016/j.avsg.2021.10.074
- 13 Gignoux B, Bayon Y, Martin D, Phan R, Augusto V, Darnis B, Sarazin M: Incidence and risk factors for incisional hernia and recurrence: Retrospective analysis of the French national database. *Colorectal Dis* 23(6): 1515-1523, 2021. DOI: 10.1111/codi.15581
- 14 Van Rooijen MMJ, Kroese LF, Van Vugt JLA, Lange JF: Sarcomania? The inapplicability of sarcopenia measurement in predicting incisional hernia development. *World J Surg* 43(3): 772-779, 2019. DOI: 10.1007/s00268-018-4837-x
- 15 Morris-Stiff G, Coles G, Moore R, Jurewicz A, Lord R: Abdominal wall hernia in autosomal dominant polycystic kidney disease. *Br J Surg* 84(5): 615-617, 1997.
- 16 Sugerman HJ, Kellum JM, Reines HD, Demaria EJ, Newsome HH, Lowry JW: Greater risk of incisional hernia with morbidly obese than steroid-dependent patients and low recurrence with prefascial polypropylene mesh. *Am J Surg* 171(1): 80-84, 1996. DOI: 10.1016/S0002-9610(99)80078-6
- 17 Nagao J, Sumiyama Y, Hara S, Saida Y: Clinical study of abdominal incisional hernia. *J Jpn Pract Surg Soc* 57: 533-537, 1996.
- 18 Israelsson L: Incisional hernias in patients with aortic aneurysmal disease: the importance of suture technique. *Eur J Vasc Endovasc Surg* 17(2): 133-135, 1999. DOI: 10.1053/ejvs.1998.0726
- 19 Deerenberg EB, Harlaar JJ, Steyerberg EW, Lont HE, Van Doorn HC, Heisterkamp J, Wijnhoven BP, Schouten WR, Cense HA, Stockmann HB, Berends FJ, Dijkhuizen FPH, Dwarkasing RS, Jairam AP, Van Ramshorst GH, Kleinrensink G, Jeekel J, Lange JF: Small bites versus large bites for closure of abdominal midline incisions (STITCH): a double-blind, multicentre, randomised controlled trial. *Lancet* 386(10000): 1254-1260, 2015. DOI: 10.1016/S0140-6736(15)60459-7
- 20 Yasuda S, Tomita K, Kiya K, Hosokawa K: STRATAFIX for abdominal wall repair following abdominal flap harvest. *Plast Reconstr Surg Glob Open* 5(11): e1572, 2017. DOI: 10.1097/GOX.0000000000001572

*Received July 10, 2023*

*Revised August 6, 2023*

*Accepted August 7, 2023*