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Long-term Outcome After Nonvascularized Rectus Fascia Transplantation in Solid Organ Transplantation: A Global Multicenter IIRTA Survey

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Background. Abdominal wall (AW) closure after solid organ transplantation (SOT) is challenging in case of loss of abdominal domain and/or large-for-size grafts. Primary closure is crucial to avoid open abdomen-associated morbidity and mortality. Several techniques have been developed to address this challenge, including nonvascularized rectus fascia transplantation (NVRF Tx). Long-term outcome is missing. **Methods.** We designed a multicenter survey to analyze the worldwide experience after NVRF Tx. International Intestinal Rehabilitation And Transplantation Association members were invited to participate to a questionnaire. The survey included all NVRF Tx performed after SOT. Questions were classified into pre-, intra-, and postoperative data. **Results.** Of the 29 responding centers, 8 performed NVRF Tx, comprising 98 patients in total. Thirty-two patients underwent multivisceral Tx (33.3%), 27 isolated intestinal Tx (28.1%), 21 combined liver-intestinal Tx (21.9%), 8 liver Tx (8.3%), 8 other SOT (8.3%), and 2 (2.0%) not reported. Thirty NVRF (30.9%) were from third-party donors. Thirty patients (31.3%) had surgical site infections. Seventy-one (74.0%) patients had reoperations, of them 18 (26.1%) patients had NVRF removal. Median follow-up time was 31 mo (10.0–63.5). Seventeen patients presented with bulging of the AW (18.7%), 5 with herniation (5.9%). No NVRF graft rejection was reported. **Conclusions.** This survey reports long-term outcome after NVRF Tx, with herniation in a limited number of patients, no suspicion of clinical rejection and no additional infection and mortality. NVRF Tx has proven to be a useful option, belonging to the standard armamentarium for AW closure after SOT.

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Failure of primary abdominal closure after intestinal transplantation (ITx), liver Tx (LiTx), or multivisceral Tx (MvTx) can be attributed to several factors. The majority of these patients had multiple prior abdominal surgeries, resulting in scarring and loss of flexibility of the abdominal wall (AW).[1,2] Moreover, many suffered from fistulae, wound infections, and/or short bowel syndrome. The abdominal domain is further compromised by donor/recipient size mismatch and edema.[3] All these factors contribute to a hostile and contracted AW resulting in an open abdomen requiring several reoperations, higher risk of intra-abdominal infections, fistulation, and mortality.[3,4]

Several techniques have been developed to overcome this problem.[5] Synthetic or biological meshes, tissue expanders and autologous tissue repair are used, although not recommended in a contaminated field.[6] Full-thickness AWTx is surgically and immunologically challenging and is reserved for patients in whom the entire AW has to be reconstructed (eg, in cases of pseudomyxoma peritonei).[7,8] Other options are vascularized rectus fascia, consisting of the posterior rectus fascia sheath attached to the donor liver and nonvascularized rectus fascia (NVRF Tx) .[1] NVRF was first described by Gondolesi et al[4] involving the donor rectus fascia (without muscle) implanted as an inlay patch.[1,3,9] In this technique, a midline skin incision is made and the abdominal skin and subcutaneous tissues are mobilized up to the lateral abdominal muscle group. After this dissection, the rectus block is removed from the donor through a subcostal incision along the lower cartilaginous arch of the thorax, followed by bilateral, longitudinal incisions along the lateral edge of the rectus block. After ligation of the inferior epigastric vessels, the rectus block is completely excised. The rectus muscles are then carefully removed, preserving only the fascia sheaths. In the case of a donor after circulatory death, the rectus fascia can be incised first along the line alba and, after retrieval of both halves, sutured together using Prolene sutures.[9] The NVRF procurement and Tx technique is summarized in Figure 1.

A systematic review of our group indicated beneficial short-term outcomes with NVRF in solid organ Tx (SOT).[3] However, comprehensive long-term results are lacking. This multicenter survey aimed to analyze the global experience with NVRF Tx and report on the long-term outcome regarding surgical site infections (SSI), rejection, and herniation.

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MATERIALS AND METHODS

Study Design and Population

We performed a retrospective, multicenter, international cross-sectional survey, approved by the scientific committee of the International Intestinal Rehabilitation and Transplantation Association (IIRTA) on September 22, 2021 and by the local ethical committee Leuven (MP023034). A personalized invitation was sent by e-mail, including survey manual (**Supplemental Digital Content 1, SDC**, https://links.lww.com/TXD/A779), study protocol and Excel template (**Supplemental Digital Content 2, SDC**, https://links.lww.com/TXD/A779), to all IIRTA member-centers (n = 55) between September 22, 2021, and June 28, 2022, including 3 reminders. The study was announced on the IIRTA webpage (https://tts.org/irta-about/irta-presidents-message). The centers were asked to fill out an Excel file (Microsoft 365, version 2304, 2021) for each patient. Inclusion criteria were all patients who received an NVRF in combination with SOT. There were no exclusion criteria. After completion, 2 additional e-mails were sent regarding the definition of NVRF rejection and indication for graft removal.

Data Collection

The Excel file consisted of pre-, peri- and postoperative variables.

The preoperative data included: recipient characteristics (age, sex, length, weight, diabetes, prior ostomies/laparotomies, transplant history, induction and maintenance immunosuppression), indication and type of SOT (MvTx, modified MvTx, combined liver-intestinal [cLi-ITx], isolated ITx, kidney, LiTx or other), and Tx-date.

The perioperative data included solid organ donor characteristics (date of Tx, age, sex, length and weight), NVRF donor characteristics (same donor as organ donor [if not: third-party NVRF], age, sex, length and weight), procedural details of NVRF procurement (incision for procurement, preservation solution/method, and cold ischemia time), and procedural details of NVRF Tx (incision, native fascia defect, single/double fascia sheath, multiple fasciae, position of the graft [inlay, onlay, or underlay], type of NVRF fixation [running/interrupted sutures], use of additional mesh material, primary skin closure and if not, use of wet dressings, vacuum-assisted closure [VAC] therapy or other techniques, as well as contact of NVRF to the outside world at end of the Tx procedure).

The postoperative data included presence of wound dehiscence (with or without fascial dehiscence), SSI (superficial, deep, and/or exposure of NVRF), rejection and loss of transplanted organ(s), rejection of the transplanted NVRF, need for reoperation (date, reason, management of wound/soft tissue closure, removal of transplanted organ/fascial allograft, and macroscopic aspect of NVRF), and the date of and clinical evaluation at the last follow-up (abdominal bulging, clinical or radiological herniation and death/alive).

Statistics

All filled-in questionnaires were collected in an Excel database. For each variable, the proportion (percentage) was calculated based on the total amount of cases for which the variable was reported. Continuous variables were characterized by median and interquartile range (P25–P75).

RESULTS

Response Rate

From 55 transplant centers contacted, 26 (47.3%) did not reply. Seventeen of 29 (58.6%) centers that replied had no patients who underwent NVRF Tx. Four of 12 centers that had clinical experience in NVRF Tx did not provide patient data (Figure 2A). Data were obtained from 98 patients from 8 centers worldwide. Figure 2B shows all participating centers. Annual case numbers and number of cases per de-identified participating center are visualized in Figure 3A and B, respectively.

Donor Characteristics (Solid Organ and NVRF)

Solid organ donor age was 19 y (9–33; length: 1.66 m [1.60–1.71]; weight: 56.50 kg [34.75–69.25]). Fifty-one donors were male. In the majority of cases, an isolated ITx, cLi-ITx, or MvTx was performed (respectively, 28.1%, 21.9%, and 33.3%; Table 1).

In thirty (30.9%) procedures, a third-party NVRF was used. In 1 case, it was transplanted simultaneously with the SOT, and in the other 29, it was used for delayed repair, with a median delay of 49.5 d (9–123). The NVRF donor age was 22 y (14.25–39.00; length: 1.68 m [1.60–1.75]; weight: 62.00 kg [50.25–70.00]). Forty-seven donors were male. The NVRF graft originated in 94 (99.0%) cases from donation after brain death. For procurement, a midline or bisubcostal incision was mainly performed (54.2% and 30.1%, respectively). Cold ischemic time was 9 h and 45 min (4–128 h). NVRF was preserved in University of Wisconsin solution in 73 (76.8%) procedures, in histidine-tryptophan-ketoglutarate solution in 9 (9.5%), Celsior in 3 (3.2%), Institut Georges Lopez-1 in 3 (3.2%) and StoreProtect Plus in 1 (1.1%) procedure(s). One center (Miami) reported cryopreservation at –60°C in 6 cases, without specifying preservation intervals (**Supplemental Digital Content 3, SDC,** https://links.lww.com/TXD/A779). In all other cases, the NVRF graft was stored on ice or in a fridge at 4 °C (maximum: 128 h).[10]

Recipient Characteristics (NVRF)

Indication for SOT was parenteral nutrition-associated liver disease in 27 (27.6%), specific pediatric-related (necrotizing enterocolitis, gastroschisis, biliary, and intestinal atresia) in 13 (13.3%), short bowel in 12 (12.2%), desmoid tumor in 11 (11.2%), porto-(mesenteric) thrombosis in 10 (10.2%), lack/loss of venous access in 10 (10.2%), and cirrhosis in 8 (8.2%) cases (Table 2). NVRF recipient's age was 35 y (16.75–49.25; length: 1.60 m [1.54–1.69]; weight: 51.50 kg [35.75–66.73]) with 26.5% being pediatric patients; 58 (59.2%) patients were female. Diabetes was present in 7.4%. Ninety-five (96.9%) patients had prior laparotomy and 61 (62.2%) had an ostomy in their medical history. Twenty-four (25.0%) patients had a previous SOT. Induction immunosuppression was alemtuzumab (46.3%), antithymocyte globulin (35.8%), steroids (11.6%), or basiliximab (8.4%). Maintenance immunosuppression consisted

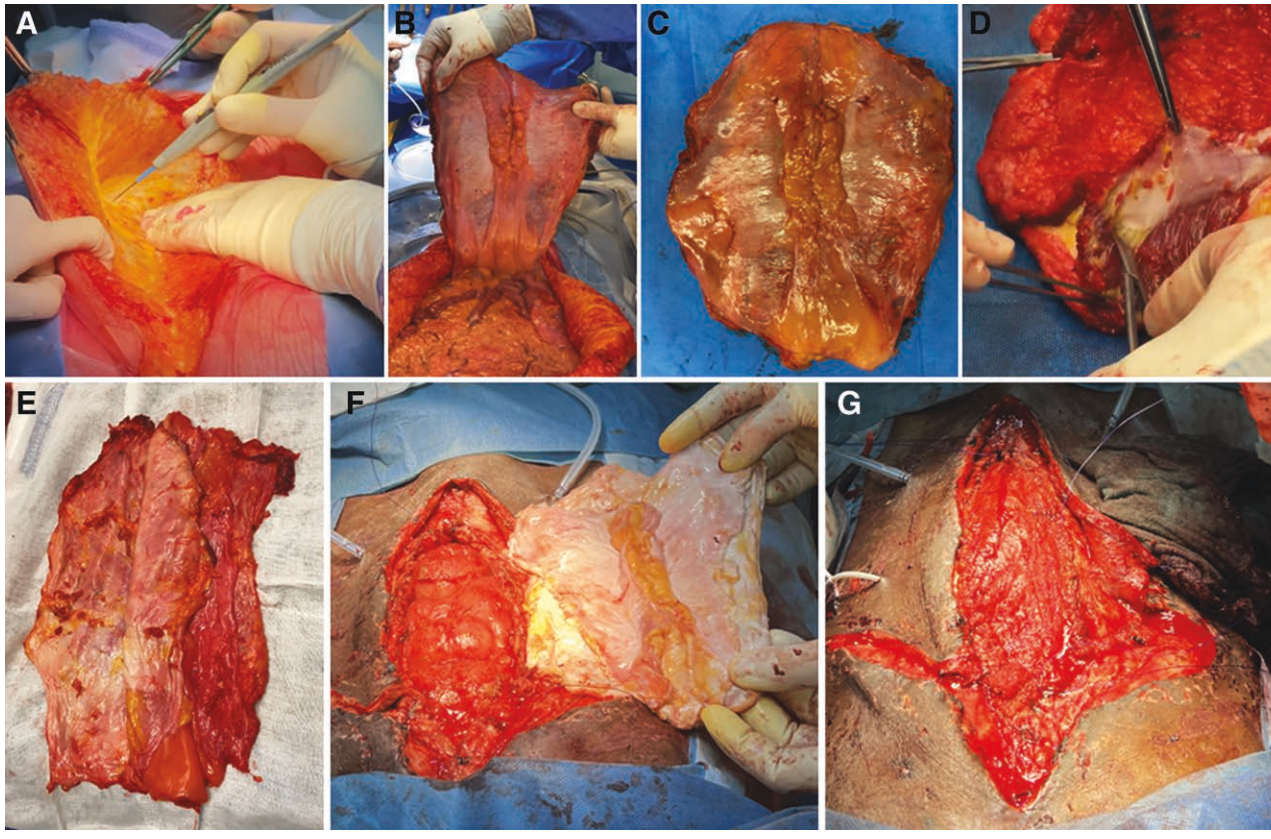

FIGURE 1. NVRF procurement and transplantation technique. A, After a median abdominal incision extending to the level of the anterior rectus fascia, bilateral dissection is carried out along the lateral abdominal musculature. B and C, After dissection, the rectus block (consisting of peritoneum, posterior rectus fascia sheath, rectus muscles and anterior rectus fascia sheath) is removed. D, On the bench table, the rectus muscles are removed. E, The anterior and posterior rectus fascia sheath after rectus muscle removal. F, Both fascia sheaths are sutured into the recipient's abdominal wall defect with a continuous running suture. G, After complete suturing of the NVRF in the recipient, the skin is closed primarily. If not possible, VAC therapy may be applied over the fascia. NVRF, nonvascularized rectus fascia; VAC, vacuum-assisted closure.

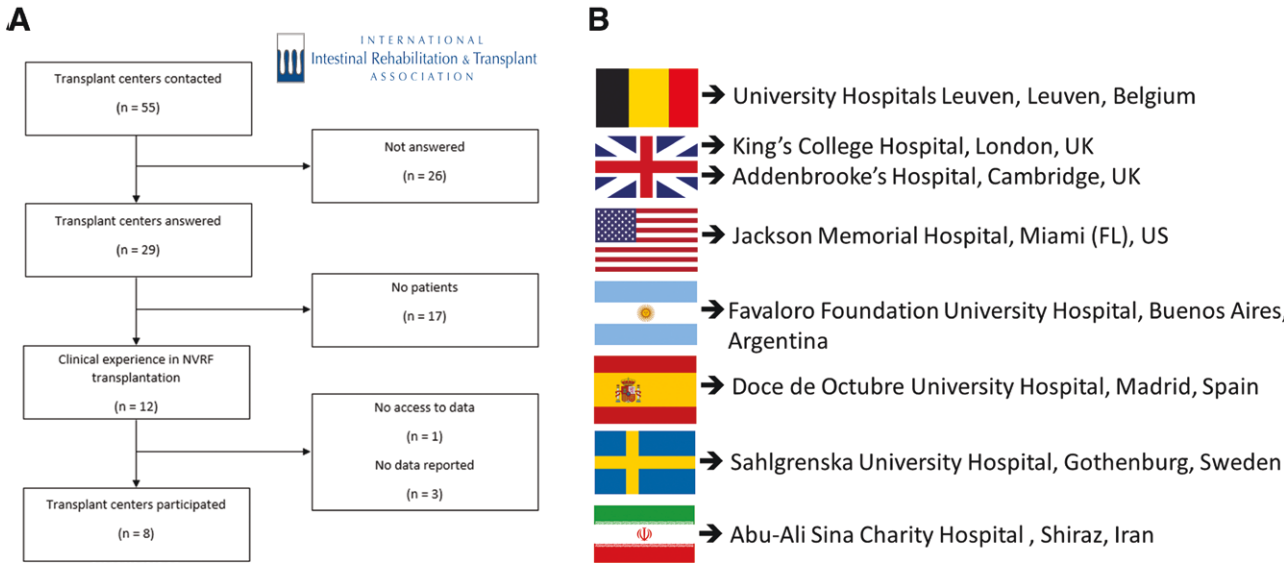

FIGURE 2. Response rate to survey. A, The inclusion process. B, Participating centers.

of tacrolimus (94.6%), mycophenolate mofetil (45.2%) and steroids (45.2%; **Supplemental Digital Content 3, SDC,** https://links.lww.com/TXD/A779).

Surgical Procedure

For Tx, a midline laparotomy was performed in 67 (68.4%) cases (Table 3). The native fascia defect was 22 cm (19–25) to 9 cm (8–10), and the 2 NVRF layers were used in 86 (87.8%) cases. The NVRF was sutured inlay in 85 (86.7%) patients and was mostly fixed with a running suture (68.4%). In 5 (5.2%) cases, >1 fascia was used to cover the defect. After NVRF Tx, additional mesh material was used in 4 (4.3%) patients (temporary silastic mesh or acellular dermal matrix allograft) and primary skin closure was obtained in 77 (81.9%) patients. In case not, wet dressings and VAC therapy were applied in 9 (56.3%) and 7 (43.8%) patients, respectively. Delayed NVRF Tx was performed in 32 of 79 (40.5%) reported cases, with a delay of 27 d (7–115).

Outcome

Wound dehiscence of the skin occurred in 21 (22.1%) patients, accompanied by a dehiscence of the NVRF in 7 (7.4%) cases (Table 4). Surgical sites were infected in 30 (31.3%) patients. In the post-Tx period, a reoperation (including all operations following the index procedure) was performed in 71 (74.0%) patients. Reasons were intra-abdominal infections in 8 (13.3%), solid organ rejection in 6 (10.0%), stoma management in 12 (20.0%), bleeding in 12 (20.0%), and evisceration in 2 (3.3%) cases, others are indicated in Table 4. During re-interventions, fascial dehiscence was observed and closed in 7 (10%) cases and the NVRF was removed in 18 (26.1%) cases (6 because of acute rejection of the solid organ, 4 because of intra-abdominal infection, 3 for evisceration/open wound, 1 because of hemoperitoneum and 1 for abdominal pain, in 3 cases no reason was given), whereas the transplanted organ was removed in 8 (11.4%) patients. In 32 (33.7%) cases, organ rejection occurred; however, in none, clinical rejection of the NVRF was reported. Overall follow-up was 31 mo (10–63.5). Overall abdominal bulging and clinical herniation was observed in respectively 17 (18.7%) and 5 (5.9%) patients (of which 2 confirmed by radiological evaluation). One patient was treated by mesh repair. Bulging and herniation in patients who survived at least 3 y was 12.8% and 11.1%, respectively. Conditional outcome is summarized in Table 5. The use of third-party graft or delayed NVRF Tx did not result in a different outcome (**Supplemental Digital Content 4 and 5, SDC,** https://links.lww.com/TXD/A779). Half (51.0%) of the patients died during follow-up but none of them because of fascia-related complications.

DISCUSSION

This IIRTA survey reports the largest global experience with and long-term outcome after NVRF Tx in 98 cases from 8 centers. Clinical rejection was not reported and NVRF could withstand infections. Furthermore, additional surgery was required in only 2 cases due to fascia-related complications. Herniation was observed at a lower rate than expected in this patient population. No fascia-related mortality was reported.

Originally developed in the setting of ITx and MvTx, NVRF Tx addresses the AW closure complexities, encountered in 40% of ITx/MvTx procedures.[4,11] The objective of the technique is to obtain tension-free closure of the AW to protect the transplanted organ(s) and enhance patient recovery.[3,7] Our survey also reports the use of NVRF in the setting of other SOT, demonstrating its broadening use in transplant practice. An attractive characteristic of NVRF is its technical simplicity and universal applicability.[3,5,9]

This survey includes NVRF preservation time up to 128 h , typically stored on ice or in a fridge at 4 °C.[10] Choice of preservation solution and mode is heterogeneous and center/surgeon-specific. Further research is required to investigate the potential of deep-freezing (−60 °C up to −80 °C) on the fascia's integrity and strength in a preclinical setting.[7] If successful, this could enhance the feasibility of using NVRF on demand. The predominant NVRF Tx technique involved transplanting both anterior and posterior fascia sheaths, in an inlay manner, and fixation with running sutures, whereas additional use of a synthetic or biologic mesh was rarely

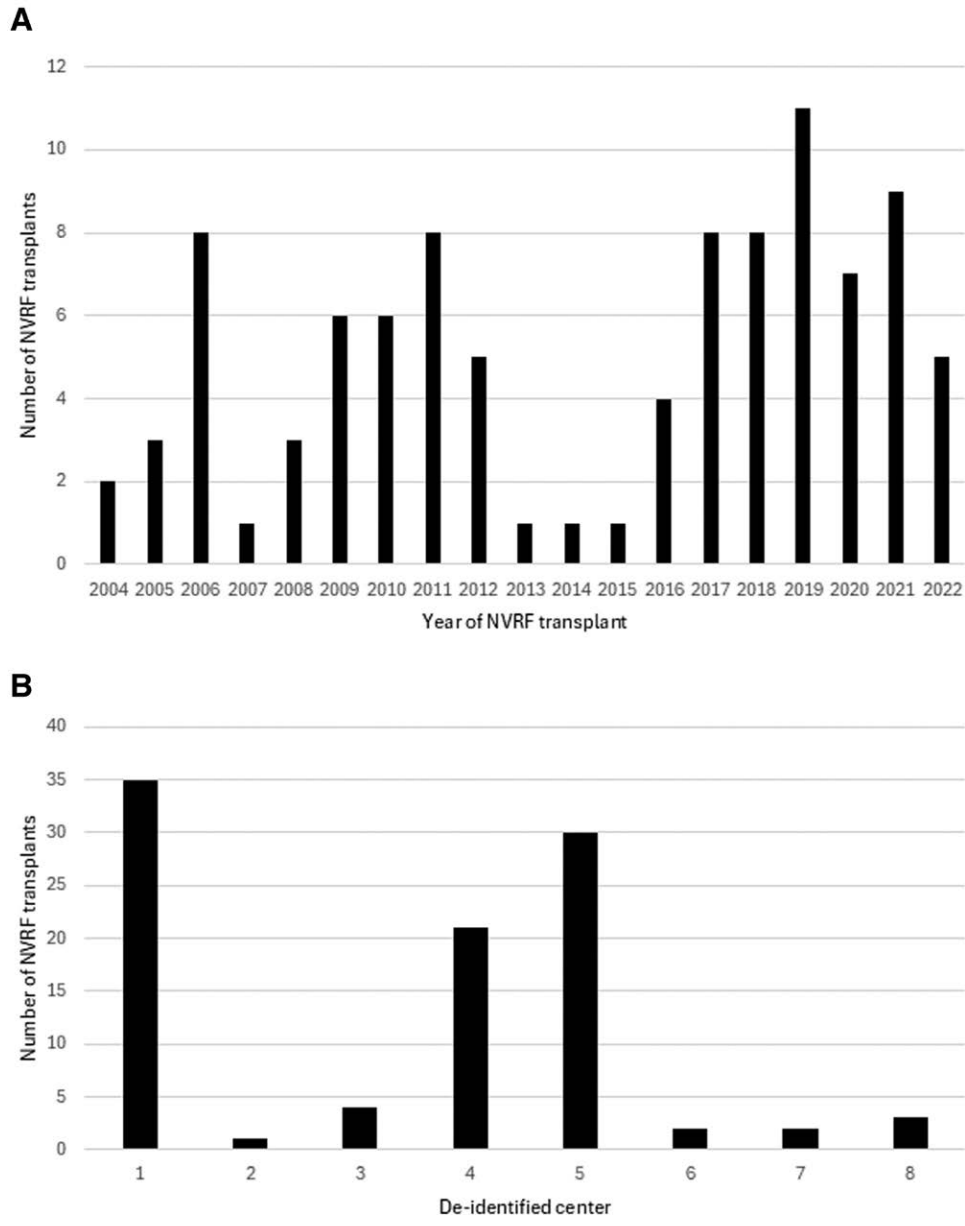

FIGURE 3. Number of NVRF Tx cases per year and per center. A, Annual NVRF Tx case numbers. B, Number of cases per de-identified participating center. NVRF, nonvascularized rectus fascia; Tx, transplantation.

reported. In most recipients, primary skin closure could be achieved. If not, VAC therapy was applied to prevent wound dehiscence, SSI, and seroma formation, and is preferred over wet dressings.[3,12] Additionally, VAC therapy can be directly placed on the fascial graft, unlike a biological mesh, where it could induce degradation.[6] Furthermore, it can help to induce neovascularization of the NVRF.[7,13] In the case of substantial skin/subcutaneous tissue defects, a full-thickness, vascularized AW graft would be the preferred option.[5,8]

A high reoperation rate is observed, which is intrinsically associated to the critical patient population from this cohort. Primary reasons for reoperations were not fascia-related, besides 2 cases of evisceration. Dehiscence (7.4%) was a rare finding, highlighting the strength and ingrowth capacity of NVRF. SSIs were the most common reported morbidity. The high incidence of SSI in this patient population, reaching up to 50%, depending on the transplanted organ, is consistent with existing literature.[14] Contrary to previous reported concerns, infections did not originate from the NVRF graft which demonstrated its value even in infected environment, surpassing the use of biological meshes. Notably, NVRF was never reported as the source of infection. In 26.1%, fascia removal was deemed necessary by the operating team, because of the septic environment after intra-abdominal infections, although no signs of fascia infection were reported. However, in most cases, the fascia could be preserved during reoperations, even allowing midline incisions as previously reported.[7]

We hypothesize that the critical period for infection is the initial 2 wk posttransplant when the NVRF graft is not fully integrated/neovascularized making it less accessible for antibiotics and host immune cells.[3] This mirrors the situation in lung Tx, where bronchi are prone to dehiscence and inflammation because their blood supply is not immediately restored in the recipient after Tx. Revascularization of the

TABLE 1.
Solid organ and NVRF donor characteristics

Solid organ donor characteristics	
Median age (IQR) (y)	19.00 (9.00–33.00)
Sex	Female: 43/94 (45.74%) Male: 51/94 (54.26%) NR: 4/98 (4.08%)
Median length (IQR) (m)	1.66 (1.60–1.71)
Median weight (IQR) (kg)	56.50 (34.75–69.25)
Type of transplantation	Isolated intestinal: 27/96 (28.13%) Combined liver-intestinal: 21/96 (21.88%) Multivisceral: 32/96 (33.33%) Liver: 8/96 (8.33%) Other: 8/96 (8.33%) NR: 2/98 (2.04%)
NVRF donor characteristics	
Use of third-party NVRF	Yes: 30/97 (30.93%) No: 67/97 (69.07%) NR: 1/98 (1.02%)
Type of NVRF donor	DBD: 94/95 (98.95%) DCD: 1/95 (1.05%) NR: 3/98 (3.06%)
Median age (IQR) (y)	22 (14.25–39.00)
Sex	Female: 28/75 (37.33%) Male: 47/75 (62.67%) NR: 23/98 (23.47%)
Median length (IQR) (m)	1.68 (1.60–1.75)
Median weight (IQR) (kg)	62.00 (50.25–70.00)
Type of incision for procurement	Bisubcostal: 25/83 (30.12%) Midline: 45/83 (54.22%) Other: 13/83 (15.66%) NR: 15/98 (15.31%)
Median cold ischemic time NVRF (min–max)	9 h 45 min (4–128 h)

DBD, donation after brain death; DCD, donation after circulatory death; IQR, interquartile range; NR, not reported; NVRF, nonvascularized rectus fascia.

TABLE 2.
NVRF recipient characteristics

Indication for solid organ Tx	PNALD: 27/98 (27.55%) Specific pediatric indications: 13/98 (13.27%) Short bowel syndrome: 12/98 (12.24%) Desmoid tumor: 11/98 (11.22%) Porto- and/or mesenteric thrombosis: 10/98 (10.20%) Lack/loss of venous access: 10/98 (10.20%) Cirrhosis: 8/98 (8.16%) Other: 17/98 (17.35%)
Median age at moment of NVRF Tx (IQR) (y)	35.00 (16.75–49.25)
Sex	Female: 58/98 (59.18%) Male: 40/98 (40.82%)
Length, median (IQR) (m)	1.60 (1.54–1.69)
Weight, median (IQR) (kg)	51.50 (35.75–66.73)
Diabetes	Yes: 7/95 (7.37%) No: 88/95 (92.63%) NR: 3/98 (3.06%)
Abdominal wall history	
Ostomy	Yes: 61/98 (62.24%) No: 37/98 (37.76%)
Prior laparotomy	Yes: 95/98 (96.94%) No: 3/98 (3.06%)
Re-solid organ Tx	Yes: 24/96 (25.00%) No: 72/96 (75.00%) NR: 2/98 (2.04%)
Type of organ of first Tx	Isolated intestinal: 8/24 (33.33%) Liver: 7/24 (29.17%) Combined liver-intestine: 4/24 (16.67%) Multivisceral: 2/24 (8.33%) Liver-intestine-pancreas: 1/24 (4.17%) Modified multivisceral: 1/24 (4.17%) Pancreas, intestine and kidney: 1/24 (4.17%)

IQR, interquartile range; NR, not reported; NVRF, nonvascularized rectus fascia; PNALD, parental nutrition-associated liver disease; Tx, transplantation.

bronchi occurs 2–4 wk post-Tx.[15] To prevent infection during this critical period, complete skin coverage or VAC therapy is essential. Adding gentamycin to the fascia preservation solution has been reported.[10,16]

In the literature, the incidence of herniation ranges from 1.7% to 32.4% after LiTx and from 13% to 34.8% in pancreas Tx, with SSI identified as the strongest risk factor for hernia formation.[17] The overall hernia rate in non-Tx patients of equivalent complexity is estimated at 32%.[18] In comparison, NVRF appears robust in preventing hernia development.[10] The overall solid organ loss in this study was 41% which is notably high. However, this finding may be influenced by selection bias, because NVRF is typically used in more complex cases. Additionally, in some instances, NVRF was transplanted as a secondary procedure after the initial SOT. Thus, NVRF Tx is not necessarily causally associated with an increased risk of solid organ loss. The cumulative mortality reached 51% over a median follow-up of 31 mo (10–63.5). In ITx, the registry-reported 1- and 5-y survival rates are approximately 74%–80% and 48%–50%, respectively.[19] Graft function and complications related to immunosuppressive medication are the most important threats to long-term survival, with rejection, infection, and renal failure being the leading causes of death in this patient population.[20,21]

Another important aspect is the immunogenicity of the NVRF. No clinical rejection was reported in this cohort. Although there is no specific definition for acute rejection of NVRF, potential indicators could be fever, erythema, and warmth in the overlying skin. Biopsies of the NVRF to definitively exclude rejection were not conducted in most centers, except for a single case in Leuven, as previously reported.[22] Standard immunosuppression, in accordance with hospital-specific protocols for SOT, was administered in each case, with no adjustments for NVRF Tx. Validated animal models are needed for further investigation, with preliminary results already published in rabbits and rats.[23-25] NVRF offers an immunological advantage as ABO- and HLA matching is not required due to its low additional immunogenicity. The low immunogenicity and avascularity of NVRF allows for the use of third-party NVRF without evident clinical repercussions. However, caution is advised, as some patients have found to develop donor ABO- and HLA-specific antibodies against third-party NVRF.[5,22,26]

Closure of the abdomen after Tx can be achieved by a variety of techniques, according center/surgeon's preference. Synthetic and biological meshes are commonly used, but they present limitations, particularly in cases requiring multiple surgeries or in the presence of a contaminated surgical field. Furthermore, the use of these meshes is associated with an increased risk of infection, which can necessitate further

TABLE 3.
Surgical procedure

Type of incision for Tx	Midline laparotomy: 67/98 (68.37%) Cruciate: 8/98 (8.16%) Mercedes: 6/98 (6.12%) Bisubcostal: 5/98 (5.10%) Other: 12/98 (12.24%)
Dimensions of native fascia defect	
Median length (IQR) (cm)	22 (19–25)
Median width (IQR) (cm)	9 (8–10)
Single/double layer	Single layer: 12/98 (12.24%) Double layer: 86/98 (87.76%)
Multiple fasciae	Yes: 5/97 (5.15%) No: 92/97 (94.85%) NR: 1/98 (1.02%)
Position of the graft	Inlay: 85/98 (86.73%) Onlay: 8/98 (8.16%) Underlay: 5/98 (5.10%)
Type of fixation	Running: 65/95 (68.42%) Interrupted: 30/95 (31.58%) NR: 3/98 (3.06%)
Use of additional mesh material	Yes: 4/94 (4.26%) No: 90/94 (95.74%) NR: 4/98 (4.08%)
Primary skin closure	Yes: 77/94 (81.91%) No: 17/94 (18.09%) NR: 4/98 (4.08%)
If not	Wet dressing: 9/16 (56.25%) VAC therapy: 7/16 (43.75%) Other: 1/16 (6.25%) NR: 1/17 (5.88%)

IQR, interquartile range; NR, not reported; Tx, transplantation; VAC, vacuum-assisted closure.

TABLE 4.
Outcome

Wound dehiscence	
Yes	Skin: 21/95 (22.11%) Fascia: 7/95 (7.37%)
No	74/95 (77.89%)
NR	3/98 (3.06%)
Surgical site infection	Yes: 30/96 (31.25%) No: 66/96 (68.75%) NR: 2/98 (2.04%)
Superficial	16/30 (53.33%)
Deep	18/30 (60.00%)
Exposure of NVRF	12/30 (40.00%)
Reoperation	Yes: 71/96 (73.96%) No: 25/96 (26,04%) NR: 2/98 (2.04%)
Reason for reoperation	Intra-abdominal infection: 8/60 (13.33%) SO rejection: 6/60 (10.00%) Stoma management: 12/60 (20.00%) Bleeding: 12/60 (20.00%) Evisceration: 2/60 (3.33%) Other unique reasons: 20/60 (33.33%) NR: 11/71 (15.49%)
Major interventions during reoperation	
Management of wound/soft tissue	Yes: 24/70 (34.29%) No: 46/70 (65.71%) NR: 1/71 (1.41%)
Closure of fascial dehiscence	Yes: 7/70 (10.00%) No: 63/70 (90.00%) NR: 1/71 (1.41%)
Removal of transplanted solid organ	Yes: 8/70 (11.43%) No: 62/70 (88.57%) NR: 1/71 (1.41%)
Removal of NVRF	Yes: 18/69 (26.09%) No: 51/69 (73.91%) NR: 2/71 (2.82%)
Rejection of transplanted solid organ	Yes: 32/95 (33.68%) No: 63/95 (66.32%) NR: 3/98 (3.06%)
Rejection of NVRF	Yes: 0/94 (0.00%) No: 94/94 (100.00%) NR: 4/98 (4.08%)
Solid organ loss	Yes: 40/97 (41.24%) No: 57/97 (58.76%) NR: 1/98 (1.02%)
Median length of follow-up (mo) (IQR)	31 (10.00 – 63.5)
Abdominal wall findings	
Abdominal bulging	Yes: 17/91 (18.68%) No: 74/91 (81.32%) NR: 7/98 (7.14%)
Clinical hernia	Yes: 5/85 (5.88%) No: 80/85 (94.12%) NR: 13/98 (13.27%)
Radiographic hernia	Yes: 2/72 (2.78%)* No: 70/72 (97.22%) NR: 26/98 (26.53%)
Patient death	Yes: 50/98 (51.02%) No: 48/98 (48.98%)

*Same herniations as reported in 5 of 85 clinical hernia.
IQR, interquartile range; NR, not reported; NVRF, nonvascularized rectus fascia; SO, solid organ.

surgical intervention, leading to prolonged hospital stays and significant socioeconomic costs. Also, synthetic meshes have been linked to higher postoperative pain, whereas biological meshes are accompanied by a substantially higher cost.[2]

Besides NVRF Tx, vascularized rectus fascia Tx is another technique used for AW closure, where the posterior rectus fascia is procured en bloc with the donor liver. This procedure is exclusive to LiTx, as the rectus fascia receives vascularization via the falciform ligament connected to the donor liver.[27] Typically, this is performed in children. Another option is full-thickness AW-Tx, which was first described by Levi et al[8] involving a vascular composite tissue allograft Tx. Only 6 centers worldwide reported this procedure with a total of 44 patients.[28] This technique is time-consuming, complex, and more prone to risks such as infarction or rejection. It is therefore reserved for cases of extensive and severe damage of the complete AW when all other reconstructive options are exhausted.[3,5,8,26,28,29]

Several limitations of our study can be identified. The survey participation rate was low and the retrospective nature of the study introduces bias and incomplete data. Additionally, a clinical definition of NVRF rejection has yet to be established. It remains unclear to what extent an NVRF graft increases susceptibility to intra-abdominal infections or SSI.

Prospective studies are essential to effectively compare NVRF Tx outcome with established abdominal closure techniques and further validate its use in an SOT context. These studies should include prospective computed tomography imaging and microbial cultures obtained during both procurement and implantation, when NVRF is used. We also recommend follow-up of donor-specific antibodies. Furthermore, we suggest that the IIRTA incorporates additional variables into the International Intestinal Transplant

TABLE 5.

Conditional outcome for bulging and herniation

	Yes	No
Bulging		
6 mo	14/77 (18.18%)	63/77 (81.82%)
1 y	10/62 (16.13%)	52/62 (83.87%)
3 y	5/39 (12.82%)	34/39 (87.18%)
5 y	2/25 (8.00%)	23/25 (92.00%)
NR: 9/98		
Herniation		
6 mo	5/72 (6.94%)	67/72 (93.06%)
1 y	5/59 (8.47%)	54/59 (91.53%)
3 y	4/36 (11.11%)	32/36 (88.89%)
5 y	2/22 (9.09%)	20/22 (90.91%)
NR: 14/98		

NR, not reported.

Registry related to abdominal closure techniques and outcome, enabling to assess how NVRF Tx compares to other abdominal closure techniques. Finally, to address the remaining immunological questions, paving the path towards implementation of NVRF in the setting of non-SOT patients with complex AW defects or infectious domain, more preclinical research is needed.

In conclusion, this global multicenter survey reports long-term outcome after NVRF Tx, with herniation in a limited number of patients, no suspicion of clinical rejection and no additional infection and mortality. NVRF Tx has proven to be a useful option, belonging to the standard armamentarium for AW closure following SOT. NVRF Tx is feasible, cheap, effective and can be used in contaminated fields; therefore, it seems a promising technique besides the already existing variety of closing techniques after Tx.

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