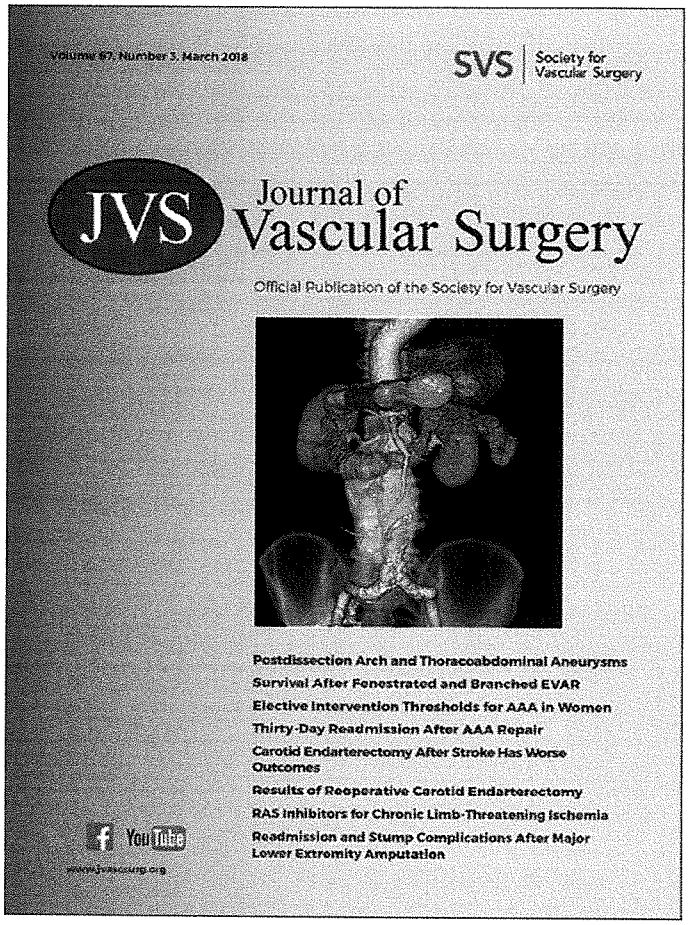

From the Society for Vascular Surgery

One-year experience of a regional service model of teleconsultation for planning and treatment of complex thoracoabdominal aortic disease

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ABSTRACT

Objective: The objective of this study was to report the methodology and 1-year experience of a regional service model of teleconsultation for planning and treatment of complex thoracoabdominal aortic disease (TAAD).

Methods: Complex TAADs without a feasible conventional surgical repair were prospectively evaluated by vascular surgeons of the same public health service (National Health System) located in a huge area of 22,994 km^2 with 3.7 million inhabitants and 11 tertiary hospitals. Surgeons evaluated computed tomography scans and clinical details that were placed on a web platform (Google Drive; Google, Mountain View, Calif) and shared by all surgeons. Patients gave informed consent for the teleconsultation. The surgeon who submits a case discusses in detail his or her case and proposes a possible therapeutic strategy. The other surgeons suggest other solutions and options in terms of grafts, techniques, or access to be used. Computed tomography angiography, angiography, and clinical outcomes of cases are then presented at the following telemeetings, and a final agreement of the operative strategy is evaluated. Teleconsultation is performed using a web conference service (WebConference.com; Avaya Inc, Basking Ridge, NJ) every month. An inter-rater agreement statistic was calculated, and the κ value was interpreted according to Altman's criteria for computed tomography angiography measurements.

Results: The rate of participation was constant (mean number of surgeons, 11; range, 9-15). Twenty-four complex TAAD cases were discussed for planning and operation during the study period. The interobserver reliability recorded was moderate (κ = 0.41-0.60) to good (κ = 0.61-0.80) for measurements of proximal and distal sealing and very good (κ = 0.81-1) for detection of any target vessel angulation >60 degrees, significant calcification (circumferential), and thrombus presence (>50%). The concordance for planning and therapeutic strategy among all participants was complete in 16 cases. In one case, the consultation was decisive for creating an innovative therapeutic strategy; in the remaining seven cases, the strategy proposed by the patient's surgeon was changed completely after the discussion. Technical success was the same (100%) if concordance in planning was present initially or not. Overall 6-month mortality was 4%, 0% for those patients with initial concordance in planning vs 12% for those without initial concordance ($P = .33$). Surgery was always performed in a tertiary hospital by local surgeons, and in two cases (8%) external surgeons joined the local surgical team.

Conclusions: Such a regional service of teleconsultation may be of value in standardizing the treatment and derived costs of complex TAADs in a huge region under the same health provider. The shared decision-making strategy may be of medical-legal value as well. (J Vasc Surg 2018;67:974-83.)

Planning and treatment of complex thoracoabdominal aortic disease (TAAD), such as complex aortic aneurysms or type B dissections, is a challenging activity for a vascular surgeon. The rapid evolution of scientific and technical knowledge with the demand by surgeons for easy and full access to high-quality information is an

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Author conflict of interest: none.

Presented partially as an oral presentation at the Forty-third Veith Symposium, New York, NY, November 16, 2016; and poster presentation at the 2017 Vascular Annual Meeting of the Society for Vascular Surgery, San Diego, Calif, May 31-June 3, 2017.

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The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

https://doi.org/10.1016/j.jvs.2017.11.043

important issue as well. In a large region with millions of inhabitants and different hospitals, there is the need to offer the same standard level of treatment for complex TAAD for each patient in all centers. Moreover, vascular surgeons do need to have the same skills, experience, and facilities. Teleconsultation can address some of these concerns and can help less experienced surgeons acquire knowledge and expertise from those more experienced.[1-4] The aim of this paper was to report the methodology and 1-year experience of a regional service model of teleconsultation for planning and treatment of complex TAAD.

METHODS

Complex TAADs without a feasible conventional surgical repair were prospectively evaluated by vascular surgeons of the same public health service (National Health System) located in a huge area of 22,994 km^2 with 3.7 million inhabitants and 11 tertiary hospitals, 3 of them university hospitals. In the same region, there are 35 nontertiary hospitals that referred complex TAADs to the center of excellence. Our group included centers at which TAAD is currently treated and centers at which it is not. Only 5 the 11 tertiary centers routinely performed TAAD repairs. The more experienced surgeons, who led the telemeetings, had at least 10 years of open and endovascular complex aortic disease treatment with a minimum overall caseload of 50 aortic cases each. Endovascular experience required knowledge of fenestrated and branched endovascular aortic repair. The caseload per year for TAAD repair for the 11 centers was as follows: one center performed 45 TAAD endovascular repairs; two centers performed 40 TAAD endovascular and open repairs; two other centers performed 15 TAAD repairs, and one center used predominantly open means and the other predominantly endovascular means. The other six centers have a caseload of fewer than five cases each per year. A total of approximately 140 TAADs are performed each year.

Surgeons evaluated computed tomography angiography (CTA) scans or angiography and clinical details, which were placed on a web platform (Google Drive; Google, *Mountain View,* Calif) and shared with all surgeons (Fig 1). Teleconsultation was performed using a web conference service (WebConference.com; Avaya Inc, Basking Ridge, NJ) every month (Fig 2). Radiologic imaging was uploaded in Digital Imaging and Communications in Medicine (DICOM) files (at least 3 days before the meeting), and participants could therefore study CTA images or angiograms using currently available DICOM viewer software. The surgeon who submitted a case discussed it in detail and proposed a possible therapeutic strategy on a PowerPoint (Microsoft, Redmond, Wash) presentation uploaded on the web platform (Fig 1). CTA images with a slice thickness of 1 mm were reconstructed using either an Aquarius (TeraRecon, San Mateo, Calif) or OsiriX (Pixmeo, Geneva, Switzerland) workstation. Multiplanar, three-dimensional, centerline reconstructions of the case were performed by the submitting surgeon. We measured proximal and distal neck lengths and diameters (considered the sealing zone), presence of any target vessel angulation >60 degrees, significant calcification (circumferential), and thrombus presence (>50%). These measurements were then compared with the measurements of other surgeons. An inter-rater agreement statistic (κ, ie, interobserver reliability) was calculated, and the κ value was interpreted according to Altman's criteria.[5] Strength of agreement was considered poor with a κ value <0.20, fair between 0.21 and 0.40, moderate between 0.41 and 0.60, good between 0.61 and 0.80, and very good between 0.81 and 1.00. The surgeons who participated at the telemeeting suggested their solutions and options in terms of grafts, techniques, or access to be used. Angiographic and clinical outcomes of cases were then presented at the following telemeetings, and a final agreement of the operative strategy was evaluated.

The protocol and informed consent were approved by the Institutional Review Board. Patients gave informed consent for the teleconsultation, and surgeons had passwords to access the Google platform and the web conference service safely.

SPSS version 15.0 software (SPSS Inc, Chicago, Ill) was used for statistical analysis.

RESULTS

Eleven telemeetings were performed in 2016, and the rate of participation at the beginning of the year was an average of 11 surgeons (range, 9-15). At the end of the first year, an average of two more surgeons had joined our group. Referral centers had two or three surgeons for complex aortic disease treatment (both endovascular and open repairs) who alternately participated in the telemeetings. Twenty-four complex TAADs, mainly aortic aneurysms (seven type II and five type IV thoracoabdominal aneurysms, nine pararenal aortic aneurysms) and three chronic type B aortic dissections, were discussed for the difficult planning and operation during the study period. These cases corresponded approximately to one-sixth of the total amount of TAADs treated in Tuscany. The concordance for planning and therapeutic strategy among all participants was complete in 16 cases (66%). In one case (4%), the consultation was decisive for creating an innovative therapeutic strategy; in the remaining seven cases (30%), the strategy proposed by the patient's surgeon was changed completely after the discussion. In general, vascular surgeons performed the procedure in their own tertiary hospitals (n = 22 [92%]). In the two remaining cases, a surgical team composed of vascular surgeons from different centers joined together in one tertiary hospital (where the patient was recovered initially) because these cases were

complex and required at least three expert surgeons for the procedure. The quality of images during teleconsultation was considered more than good and sufficient to express a medical judgment by the surgeons, who evaluated the importance of the teleconsultation on a 5-point scale (5, very important; 4, important; 3, moderately important; 2, slightly important; 1, not important).[6] A final score of 5 was given. The κ values were 0.54 (95% confidence interval [CI], 0.36-0.52) and 0.52 (95% CI, 0.45-0.69) for proximal neck length (proximal sealing zone) and diameter, 0.61 (95% CI, 0.46-0.71) and 0.65 (95% CI, 0.55-0.73) for distal neck length (distal sealing zone) and diameter, 0.95 (95% CI, 0.94-0.98) for presence of any target vessel angulation >60 degrees, 0.87 (95% CI, 0.84-0.93) for significant calcification (circumferential), and 0.81 (95% CI, 0.74-0.89) for thrombus presence (>50%). Furthermore, patients were divided into two groups: patients with concordance for planning (group A; n = 16) and patients without concordance (group B; n = 8). Group A vs group B κ values were 0.62 (95% CI, 0.49-0.65) vs 0.43 (95% CI, 0.35-0.47; $P = .02$) and 0.63 (95% CI, 0.48-0.71) vs 0.47 (95% CI, 0.41-0.55; $P = .003$) for proximal neck length and diameter, 0.69 (95% CI, 0.54-0.73) vs 0.52 (95% CI, 0.44-0.68; $P = .001$) and 0.72 (95% CI, 0.61-0.79) vs 0.58 (95% CI, 0.44-0.73; $P = .42$) for distal neck length and diameter, 0.98 (95% CI, 0.94-0.99) vs 0.94 (95% CI, 0.92-0.98; $P = .72$) for presence of any target vessel angulation >60 degrees, 0.93 (95% CI, 0.86-0.95) vs 0.86 (95% CI, 0.83-0.93) for significant calcification (circumferential; $P = .51$), and 0.86 (95% CI, 0.76-0.9) vs 0.8 (95% CI, 0.74-0.88; $P = .36$) for thrombus presence (>50%), respectively (Table).

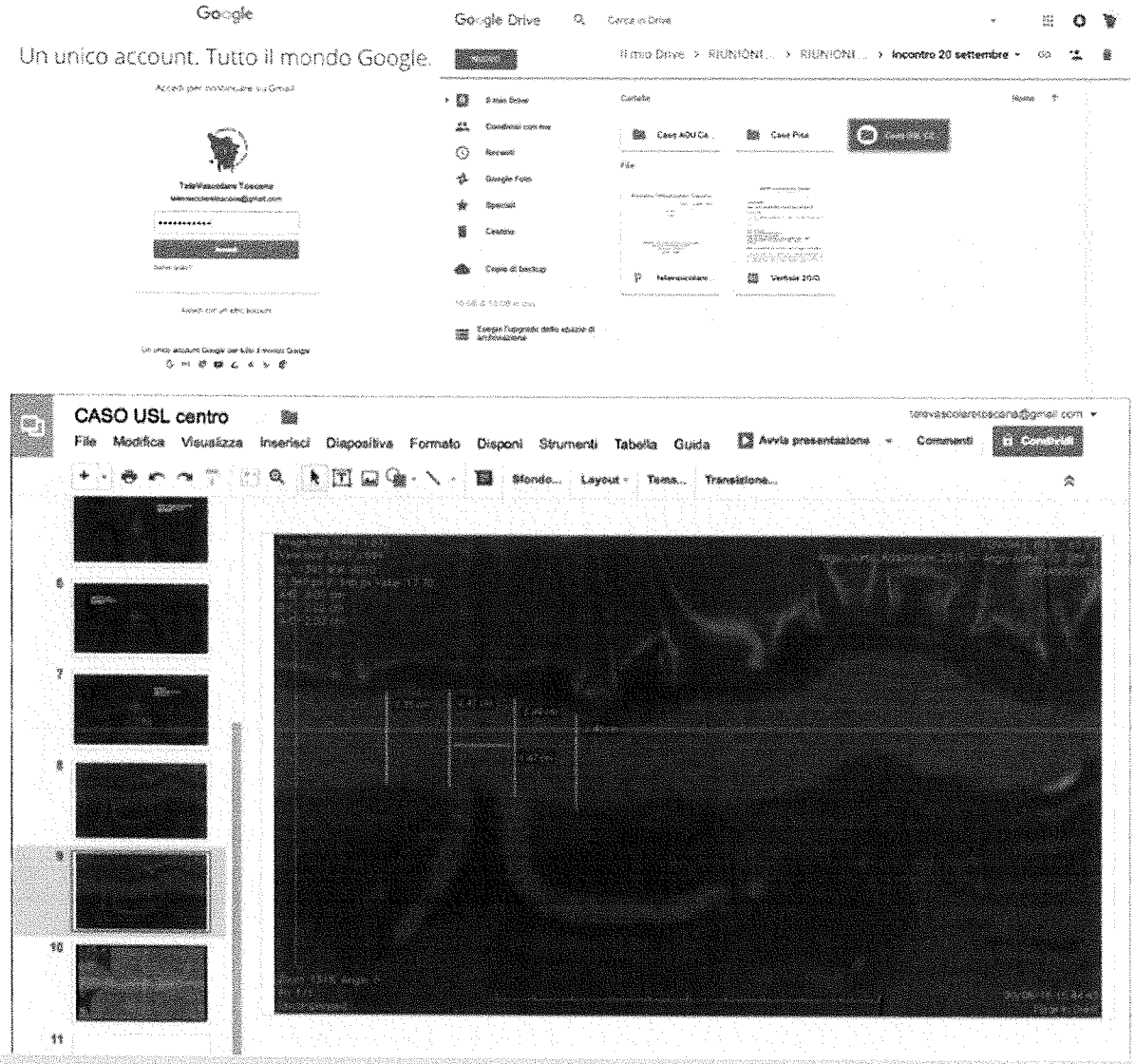


Fig 1. The web platform (Google Drive, Google, Mountain View, Calif) used for the teleconsultation. On the image below, an example of a PowerPoint (Microsoft, Redmond, Wash) presentation uploaded on the web platform to show a case.

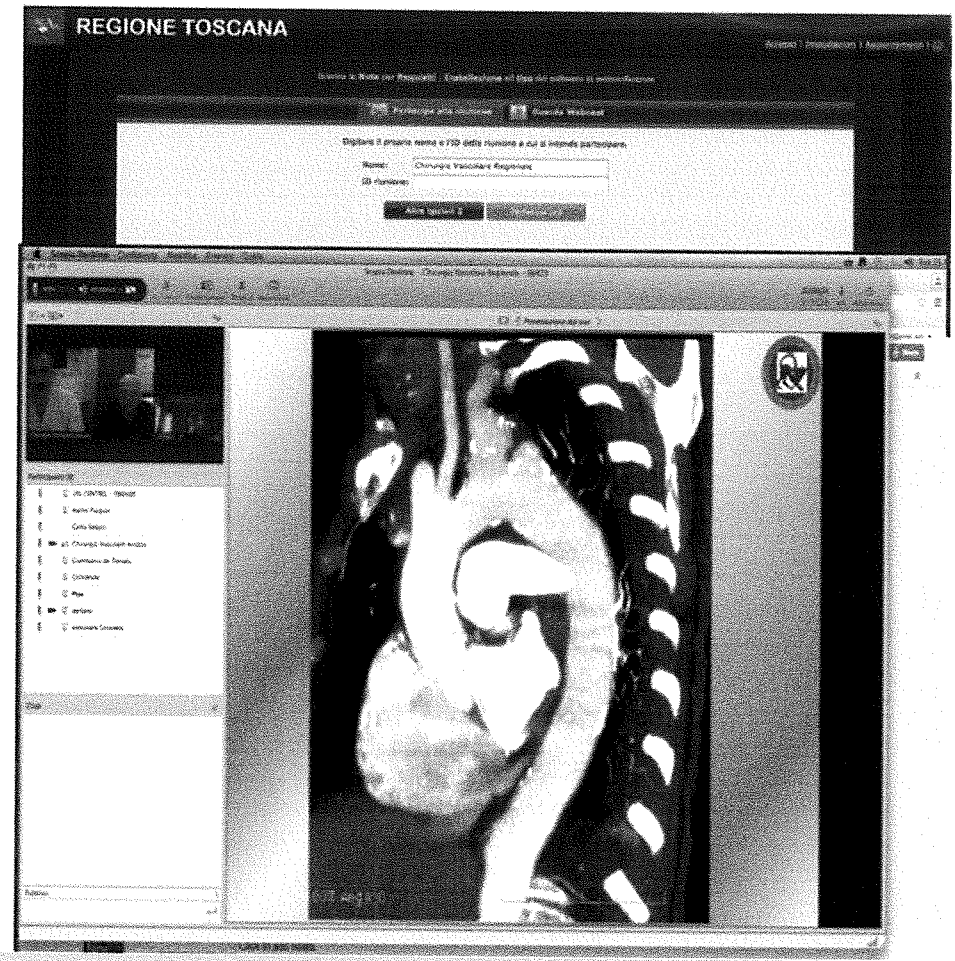


Fig 2. Teleconsultation was performed using the web conference service Avaya Inc (Basking Ridge, NJ). An example of a telemeeting is shown.

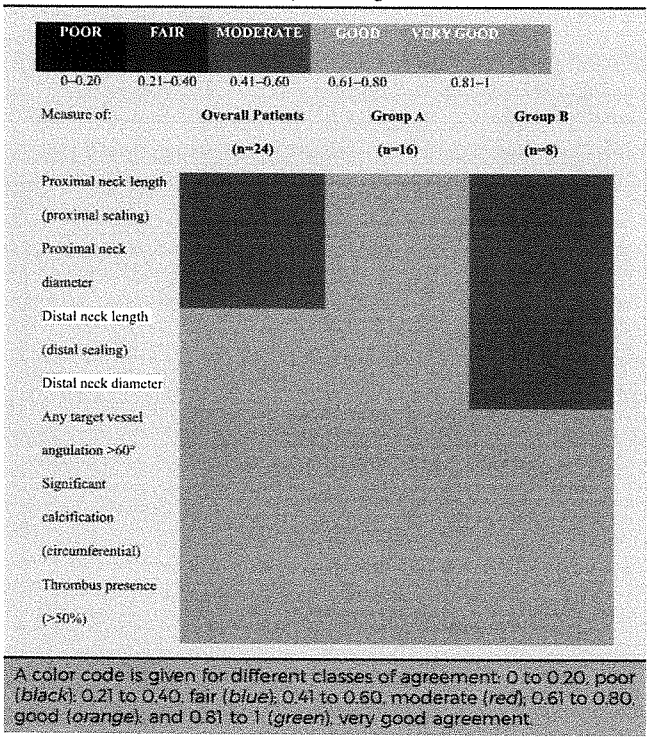
The outcomes for group A and group B were similar. Technical success was the same (100%). We recorded one aorta-related death in group B (overall mortality, 4%; group B mortality, 12% vs 0% in group A; $P = .33$); no type I and type III endoleaks or complications were recorded within the first 6 months of follow-up in either group.

The teleconference was evaluated at the end of each session, and the day after the teleconference, a report was shared with all surgeons whereby all observations, clinical decisions, therapeutic strategy, planning, and actions adopted during interventions were highlighted. Midterm follow-up was shown for patients who had completed at least the 6-month follow-up. We report two cases as examples.

Case 1. A 61-year-old man with a 67-mm type IV thoracoabdominal aortic aneurysm and a huge common and internal iliac right aneurysm (65 mm) evolved from a chronic type B aortic dissection. The patient had both systemic and anatomic high-risk profiles. He had coronary artery disease with a recent percutaneous transluminal coronary angioplasty on dual antiplatelet therapy, hypertension, and previous right nephrectomy for cancer. Regarding the anatomic issues, the false lumen was greater than the true lumen, with residual lumen at the renal portion of just 13 mm (Fig 3). The lamella had been present for >10 years and was so hard that it had to be remodeled in case of an endovascular treatment. The presence of a huge hypogastric aneurysm and a large lumbar artery increased the risk of paraplegia in case of repair. The right renal artery was absent because of a previous nephrectomy.

The case was discussed and some treatment options were highlighted: (1) close follow-up; (2) open thoracolaparotomy with visceral vessel and some lumbar artery reimplantations, occlusion of the right iliac axis and huge hypogastric aneurysm, and left to right femoral crossover; (3) total endovascular solution with a thoracic graft proximally, then a custom-made cuff produced by Cook (Cook Medical, Brisbane, Australia) with three fenestrations (superior mesenteric, celiac trunk, and right renal artery), a bifurcated graft, and iliac limbs (Excluder; W. L. Gore & Associates, Flagstaff, Ariz) because of its high

Table. The κ values for overall patients, group A (patients with concordance for planning), and group B (patients without concordance for planning)



A color code is given for different classes of agreement: 0 to 0.20, poor (*black*); 0.21 to 0.40, fair (*blue*); 0.41 to 0.60, moderate (*red*); 0.61 to 0.80, good (*orange*); and 0.81 to 1 (*green*), very good agreement.

conformability for complete relining of the right iliac axis and plug embolization of the hypogastric aneurysm; and (4) total endovascular repair with chimney/parallel grafts using standard devices. The surgical solution chosen was the third one. The critical issues of planning were overcome; therefore, paraplegia was not observed, and the true lumen in the narrowed part of the aorta of 13 mm was expanded to 18 mm (Fig 4). In particular, ballooning of the custom-made device was performed using a compliant balloon (Reliant; Medtronic, Santa Rosa, Calif) to have the maximum achievable expansion of the device at the level of the dissected aorta. Cannulation of the visceral vessels was possible in all cases, and a balloon-expandable stent (Advanta V12; Atrium Medical, Hudson, NH) was used. The 6-month follow-up was uneventful, and type II endoleak was present at the level of aortic carrefour from a lumbar artery.

Case 2. A 79-year-old man with a 60-mm type IV thoracoabdominal aneurysm was treated with use of a custom-made device graft (JOTEC GmbH, Hechingen, Germany) with four branches (two inner branches for superior mesenteric artery and celiac trunk and two external reversed branches for renal arteries; Fig 5, *A* and *B*). The visceral vessels were stented using Advanta proximally and Viabahn distally to accommodate the tortuosity better. The procedure was complicated by a type Ib endoleak, which was reduced but still persistent after intraprocedural deployment of a distal cuff and prolonged balloon inflation (Fig 5, *C* and *D*). The case was presented to discuss the possible solutions of the type Ib endoleak, considering the distance from the lowest renal branch and the aortic carrefour of 6.5 cm (Fig 6, *A*) and the presence of two grafts (the custom-made 24-mm device and the 26-mm cuff) at the level of the aorta pre-carrefour, which was 22 mm in maximum diameter with a good distal neck length of approximately 20 mm. The surgeon proposed two possible solutions: (1) placement of a Gore C3 bifurcated graft (W. L. Gore & Associates)—this option had a 4-cm main body plus a 3-cm ipsilateral limb, a total of 7 cm, which was 1 cm longer than the distance between the lowermost renal artery and the carrefour; this implantation required a deployment of the graft proximally and a pullback to accommodate the graft appropriately; and (2) placement of a unibody bifurcated AFX endovascular aortic aneurysm system (Endologix, Irvine, Calif) with a body length of 60 mm. All the surgeons approved the second solution. Therefore, endovascular aneurysm repair was performed using the Endologix AFX device with resolution of the type Ib endoleak (Fig 6, *B-D*). As a take-home message of this case, a 2-cm distal aortic calcified neck should not be considered long enough for a stable implantation; we must plan a direct landing in healthy iliac vessels.

DISCUSSION

The model of a regional teleconsultation herein proposed is simple, economically sustainable, and effective in the decision-making strategy. The preliminary results of this study show that this kind of model of teleconsultation may be of value in standardizing the treatment and derived costs of complex TAADs in a huge region under the same public health service. The shared decision-making strategy may be of medical-legal value as well. In 66% of the cases, there was concordance in planning and treatment. In the remaining 34%, discussion was important in finalizing the planning of the procedure. This is not a negligible percentage, and it shows the need of interaction and discussion among surgeons in planning and treatment of complex cases. Moreover, the interobserver reliability observed in this study for different measurements was not good among the participating surgeons, especially in the case of neck length or diameter measurements (proximal and distal sealing evaluation). A subgroup analysis showed a higher concordance in planning if there was a higher agreement in measures even if it was not perfect (Table). The main reason for the not perfect interobserver reliability was the presence of very challenging aortic anatomies. In cases of complex anatomies, tortuosity, angulation, calcification, thrombus, and in some cases dissection were present, and therefore measurements were difficult and

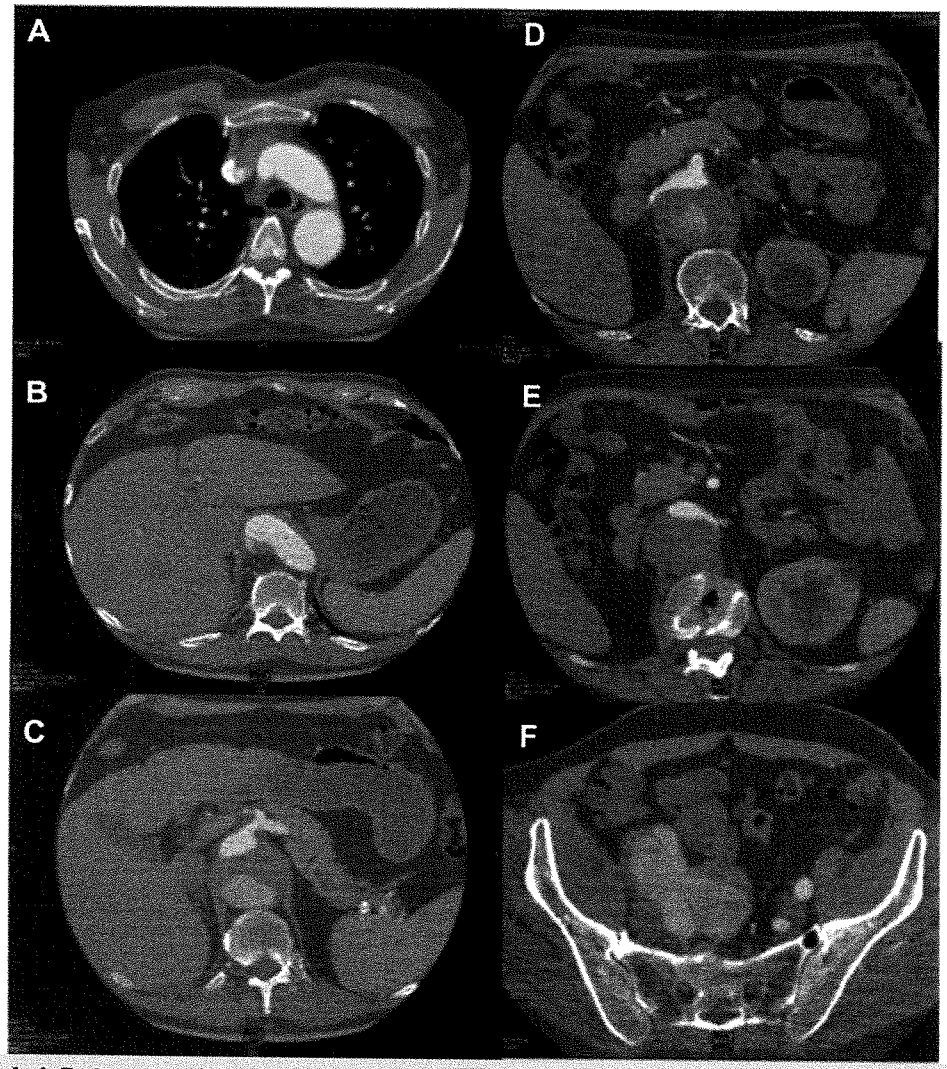


Fig 3. Case 1. **A-F,** Computed tomography angiography (CTA) of a 67-mm type IV thoracoabdominal aortic aneurysm and huge common and internal iliac right aneurysm (65 mm) evolved from a chronic type B aortic dissection. **E,** CTA detail at the level of the narrowest residual lumen at the renal portion of just 13 mm.

could not be standardized. To limit this problem, we recommend making multiple measures in different projections, without trusting the centerline measurement too much. Then, after at least three measurements, the mean values should be used for planning.

In fact, the literature demonstrated that in case of an angulated aorta, the operator must adjust the centerline according to the predicted path in which the main body will run. These processes require judgment and care of the operator and can cause interobserver disagreement.[7,8] The lack of concordance in measurements was the main cause for the 34% initial lack of concordance in planning. A major point of discussion was which aorta segment should be considered good in terms of a sealing zone. A successful endovascular procedure relies on accurate preoperative imaging for proper operative planning. The not excellent interobserver reliability of measurements herein shown may be a warning message for possible late failure, such as endoleaks, graft thrombosis, graft misalignment, and failure to exclude the aneurysm. The discussion enhanced by teleconsultation can be of value for better planning and therefore treatment of such complex aortic diseases and protect patients from adverse events. Results for group A and group B were similar, with 100% technical success and 4% 6-month mortality. Telemeetings resulted in increasing the rate of appropriate planning. All vascular surgeons attributed great importance to participation in this meeting. Furthermore, this method has never been reported for vascular surgery. Telemedicine can be beneficial to patients in isolated communities and remote regions, who can receive care from physicians or specialists far away without having to travel to visit them.[3,4,9-11] Recent developments in technology can

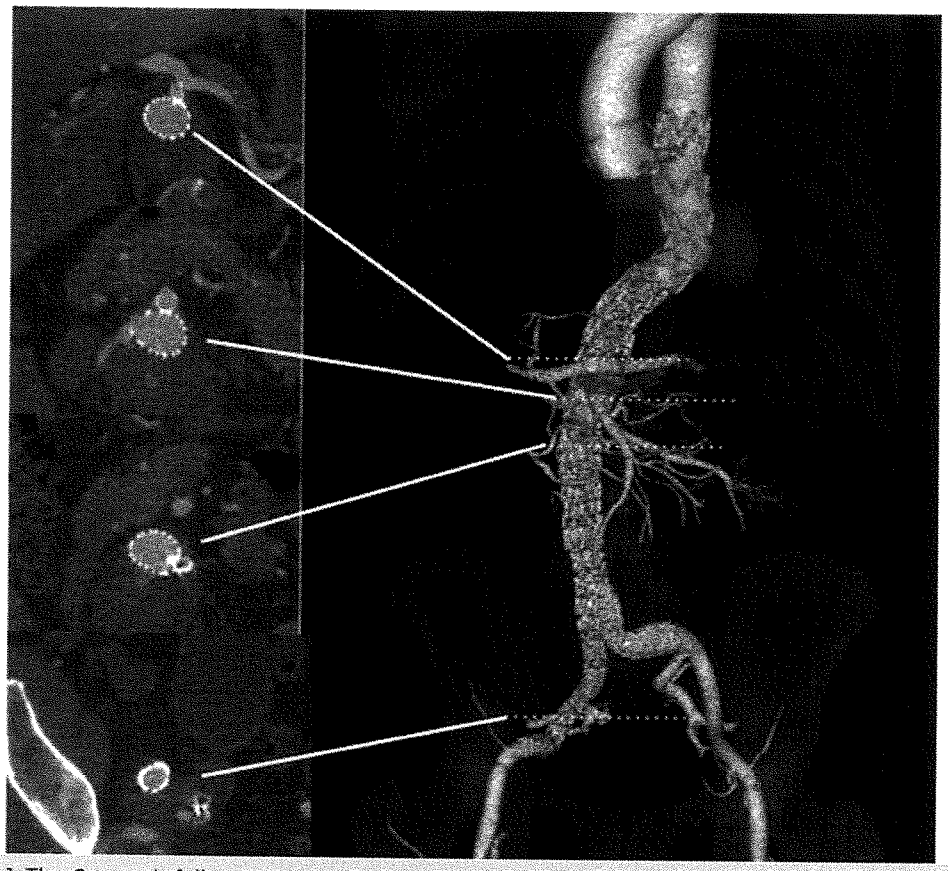


Fig 4. Case 1. The 6-month follow-up computed tomography angiography (CTA) scan showed exclusion of the aortic and iliac aneurysms and patency of celiac trunk and superior mesenteric and left renal arteries.

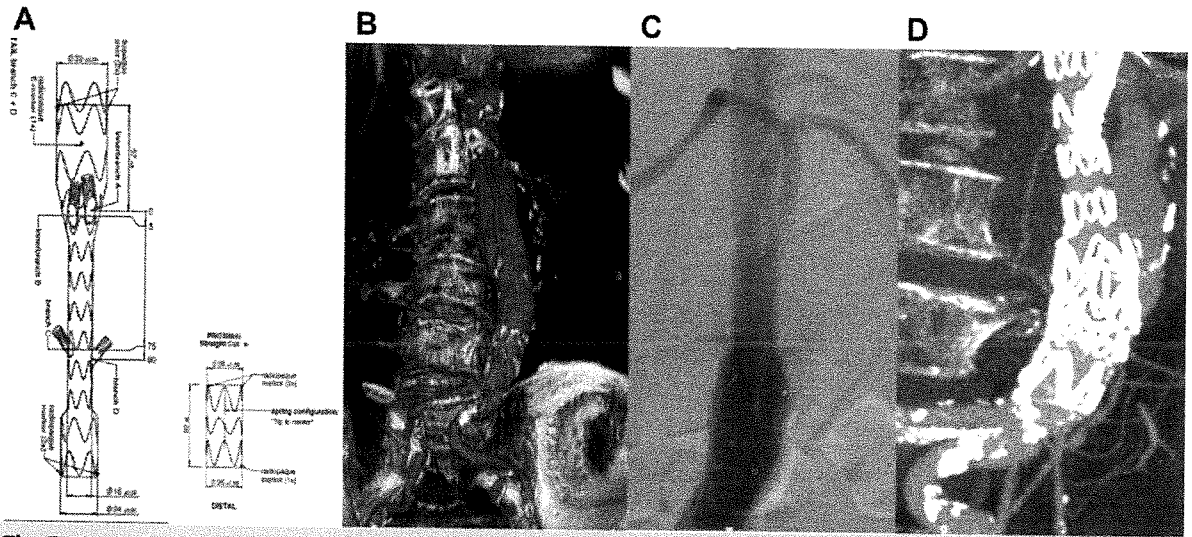


Fig 5. Case 2. **A** and **B**, Type IV thoracoabdominal aortic aneurysm and design of custom-made device. **C**, Completion angiography revealing good patency of renal debranching and type Ib endoleaks. **D**, The 1-month follow-up computed tomography angiography (CTA) scan confirming the type Ib endoleak.

allow health care professionals in multiple locations to share information and discuss patient issues as if they were in the same place. Telemedicine can also facilitate medical education by allowing workers to observe experts in their fields and share best practices more easily.[12-15] We strongly think this is one of the major accomplishments of the telemeetings we have created. Possible downsides of telemedicine include the cost of

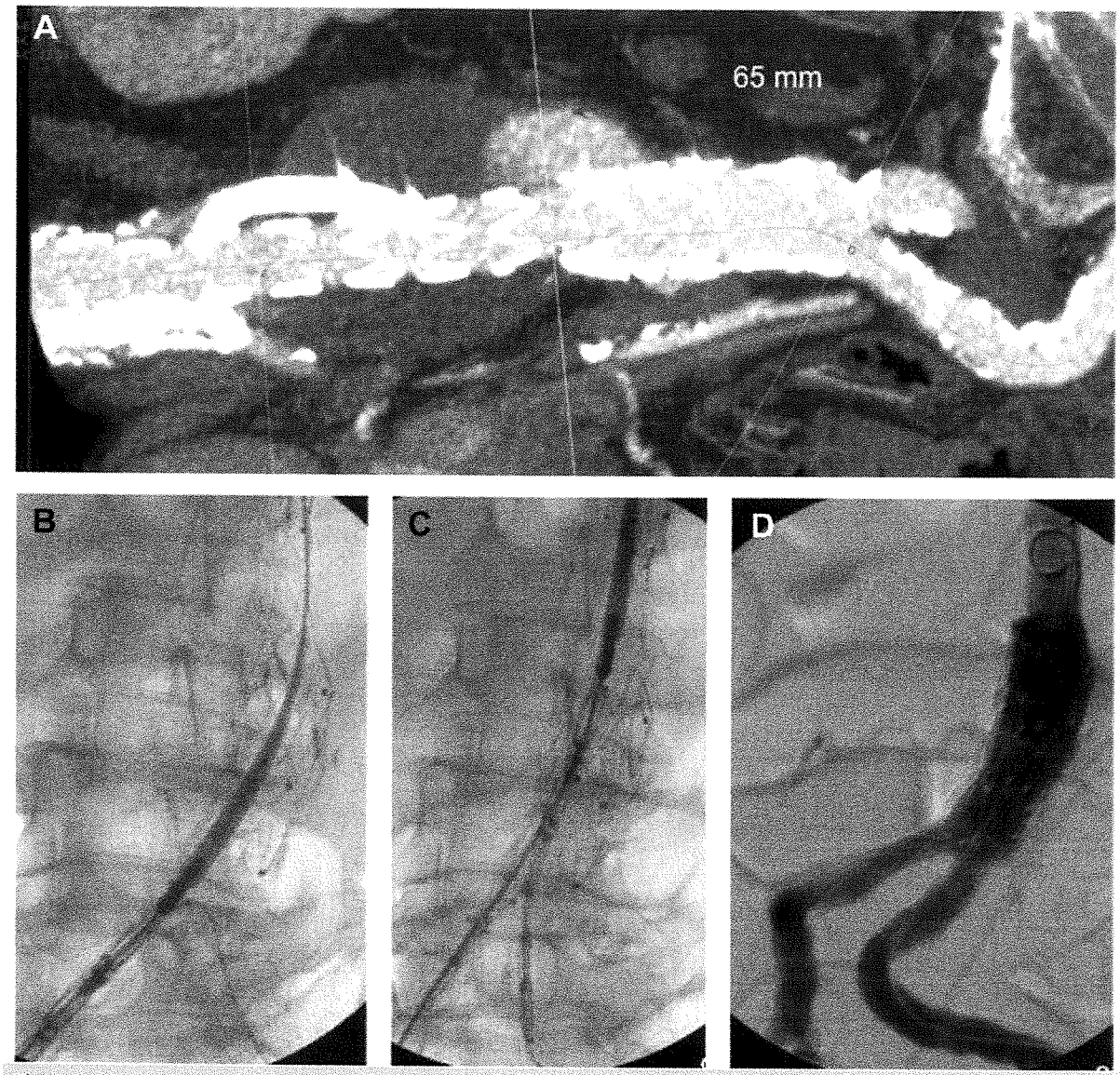


Fig 6. Case 2. **A,** The computed tomography angiography (CTA) reconstruction shows the distance from the lowest renal branch and the aortic carrefour of 6.5 cm. **B-D,** Intraoperative angiograms of endoleak resolution by placement of a unibody bifurcated AFX endovascular aortic aneurysm system (Endologix, Irvine, Calif).

telecommunication and data management equipment and of technical training for medical personnel who will employ it.[3] Regarding this issue, this service was administered by one of the surgeons during his working time with no adjunctive costs. The costs for the teleconsultation program are about €3000 per year, whereas Google Drive is free. Laptops, tablets, or smartphones used by attendees for the telemeetings were the same ones used for hospital or personal activities without adjunctive costs. Teleconsultation increased interaction between medical professionals, and patients did not need to visit different specialists to have a second or third opinion.[13] An issue is an increased risk that protected health information might be compromised through electronic storage or transmission. In addition, potentially poor quality of transmitted records, such as images or patient progress reports, and decreased access to relevant clinical information are quality assurance risks that can compromise the quality and continuity of patient care for the reporting physician.[16] This point was overcome by the storage of all data and CTA images in the Google drive files. The CTA images were reconstructed in each center using DICOM software. Other obstacles to the implementation of telemedicine include unclear legal regulation for some telemedical practices and the difficulty of claiming reimbursement from insurers or government programs in some fields. In our experience and country, legal issues are waived by the disclosure

and acceptance of the patients for the teleconsultation. This program of teleconsultation in fact was approved by the Tuscan health governor and conforms to our regional Health National System rules. This could be different in other countries or states. All patients had a positive feedback about the possibility of having a second or third opinion and more without moving or paying an extra fee. Anyway, a reimbursement fee code could be created for the health system if this kind of medical opinion is thought to be really needed. Finally, we think that strong opinions of the vascular community should be created to have a single and distinguished voice for investments and reimbursements with respect to the government authority. Telemeetings reduced the need for patients to travel but can increase the need for expert surgeons to travel and concentrate in centers of excellence to increase the skill and experience of the medical team in treating complex aortic disease, as occurred in two procedures (8%) in this preliminary experience.

CONCLUSIONS

A regional service of teleconsultation may be of value in standardizing the treatment and derived costs of complex TAAAs in a huge region under the same public health service. Teleconsultation allows surgeons to brief and debrief complex cases so that parallel multicenter and multisurgeon knowledge and skill can increase. The shared decision-making strategy may be of medical-legal value as well.

The authors would like to thank Nancy Cuff for her editorial assistance and critical revision.

AUTHOR CONTRIBUTIONS

Conception and design: EC, CS, SM
Analysis and interpretation: ED, GD, AF, GV, GP, CS, LE, SM
Data collection: ED, GD, AF
Writing the article: ED, GD, AF, GP
Critical revision of the article: ED, GD, AF, GV, GP, CS, LE, SM
Final approval of the article: ED, GD, AF, GV, GP, CS, LE, SM
Statistical analysis: ED, GD, GP
Obtained funding: Not applicable
Overall responsibility: EC

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Submitted May 26, 2017; accepted Nov 21, 2017.

APPENDIX.

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