Results from an Expert-Based Cross-Sectional National Survey on Antithrombotic TREATment After PEDiatric Peripheral Vascular Injuries. (The TREAT-PED-PVI Survey)

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Purpose: We aimed to survey the contemporary approaches on antithrombotic drugs after major pediatric peripheral vascular injuries.

Methods: Using a web-based questionnaire, we engaged physicians involved in the surgical and medical treatment of pediatric peripheral vascular injury. The survey included 24 multiple-choice questions: 7 related to the baseline demographics of panelists, 10 related to the choice of antithrombotic treatment modalities according to different clinical scenarios, 3 related to safety and hemorrhagic complications, and 4 related to follow-up considerations.

Results: Of the 50 physicians invited, 35 (70%) gave their availability: 27 (77.1%) were vascular surgeons, 7 (20.0%) angiologists/cardiologists, and 1 (2.9%) pediatric specialist. The vascular surgeon oversaw the drug regimen choice in 28 (80.0%) institutions. Aspirin was the most frequently used antithrombotic agent in end-to-end anastomosis ($n = 25$, 71.4%) and interposition vein ($n = 23$, 65.7%) or prosthetic ($n = 25$, 71.4%) grafts. Aspirin was associated with low-weight molecular heparin either in end-to-end anastomosis or interposition vein graft (28.6%, both), with anticoagulants in interposition prosthetic graft (48.6%). The most frequent (42.0%) duration of treatment was 1 to 6 months. Only a minority ($n = 9$, 25.7%) used an integrated monitoring coagulation protocol. Bleeding disorders were not experienced by most ($n = 29$, 82.9%).

Conclusion: Aspirin and low-weight molecular heparin are the most frequently used drug regimens after major pediatric vascular traumas, most frequently used in association. A multidisciplinary team evaluation is frequently adopted, but the vascular surgeon plays a major role in selecting the antithrombotic regimen.

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INTRODUCTION

Vascular traumas in the pediatric population are less common, occurring in 0.6% of all pediatric trauma patients, and/or underreported in comparison with adult traumas.[1–9] Furthermore, there is not a commonly accepted threshold to define a pediatric peripheral vascular injury (PED-PVI).[3,4,8,9]

The consequent general lack of clinical evidence makes it difficult to establish firm management recommendations from diagnosis to operative management. In particular, although there are specific recommendations on the best medical treatment after peripheral surgical reconstructions for obstructive disease, there is no clinical robustness that specifies what is the best antithrombotic treatment after peripheral trauma reconstructions and even more uncertainty exists in these scenarios in the pediatric setting.[10,11] Given the absence of dedicated guidelines to address the abovementioned issues, we aimed to survey the contemporary attitudes of a multispecialty panel of surgical and medical experts from a single country, to assess areas of consensus and zones of uncertainty that may drive the need for future research efforts.

MATERIALS AND METHODS

Study Design

A web-based questionnaire was designed by the study Core Team (G.P., M.P.D., and M.D.) to obtain a reliable picture of contemporary practice patterns of surgeons and physicians involved in surgical and medical treatment of PED-PVI. The survey was in English and reported in accordance with the checklist for reporting of survey studies (Supplementary Table 1).[12] Specifically for the aim of the study, this survey included 25 multiple-choice or open-ended questions (Supplementary Table 2). Of these, 7 were related to baseline demographics of panelists, 10 were related to choice of antithrombotic treatment modalities according to different clinical scenarios, 3 were related to safety and hemorrhagic complications, 4 were related to follow-up considerations, and the last one was left at the discretion of each respondent to include personal observations. Ethical approval for the study was not required as it did not involve patient-level data, and all analyses were conducted in aggregate.

Survey Implementation

All the physicians who were involved filled the survey anonymously on Google Forms using a dedicated link. Convenience sampling was applied for the study. Overall, we selected a total of 50 Italian opinion leaders in the field, including vascular surgeons, vascular physicians/angiologists, internists expert in thrombosis and hemostasis, and pediatricians. Given the rarity of disease and absence of dedicated clinical practice guidelines, the selection was made based on recognized clinical and/or scientific expertise in the field of peripheral vascular disease and antithrombotic treatment. Specifically, we included only those working at level 1 trauma centers or tertiary university hospitals and/or with at least 10 publications on related topics or formal authorship in professional societies endorsed clinical practice guidelines. The choice of participants was made across different regions (North, Center, South, and Isles), to obtain a reasonably representative portrait of the national landscape. The initiative started on September 1, 2024, and the survey was closed 1 month later, on October 1, 2024. To reduce nonresponse rates, the survey was designed to last no more than 10 min and reminders were sent to nonrespondents after the first 2 weeks of the initial invitation.

Definitions

Specifically for the aim of this survey, we used the consensus report from the bleeding academic research consortium for the standardization of bleeding definition: accordingly, severe bleeding was defined as $\geq$ type 3a.[13] As far as the follow-up surveillance is concerned, a graft at risk was indicated by a focal increase in peak systolic velocity (PSV) of 180–300 cm/s and a velocity ratio, defined as the PSV at the site of a stenosis divided by the PSV in a normal vessel segment proximal to the stenosis, of 2.0–3.5.[14]

Statistical Analysis

All answers were collected in a single database, recorded, and tabulated in Microsoft Excel (Microsoft Corp, Redmond, Washington). Statistical analysis was performed with SPSS, release 29.0 for Windows (IBM SPSS Inc..., Chicago, Illinois). Continuous variables were tested for normality using the Shapiro–Wilk test, and compared between groups with unpaired Student's *t*-test for normally distributed values; otherwise, the Mann–Whitney *U* test was used. Variables that were normally distributed are presented as mean ± standard deviation and range; otherwise, they are presented as median and interquartile range. Categorical variables were presented using frequencies and percentages and analyzed with the Pearson χ^2 test or Fisher

exact test whether the expected cell frequencies were <5.[15]

RESULTS

Demographic Features of Respondents

We received 35 unique responses, thereby yielding a 70% response rate. All but 3 (9.6%) respondents were males ($n = 32$, 91.4%). The most represented age range was between 40 and 50 years of age as well as 50 and 60, with 13 (37.1%) respondents in each group. Seventeen (48.6%) reported >20 years postgraduate clinical experience.

Discipline of Reference

Surgical discipline was represented only by vascular surgeons ($n = 27$, 77.1%); among nonsurgical disciplines, there were 6 (17.1%) physicians from internal medicine or angiology, and 1 (2.9%) each from cardiology and pediatric medicine. We did not observe a difference in years of experience across the different specialties ($P = 0.469$). Most of the respondents work in an academic environment, namely a university hospital ($n = 29$, 82.9%); a minority of them are working in a nonacademic public hospital ($n = 6$, 17.1%). Gender ($P = 0.869$) and years of experience ($P = 0.894$) were not different between university or nonacademic hospitals. Considering the referral specialist, in most cases ($n = 28$, 80.0%) a vascular surgeon was in charge of selecting the antithrombotic regimen but most frequently ($n = 25$, 71.4%) in conjunction with 1 or multiple other specialists (Fig. 1).

Peripheral Traumas Volume

In the last 5 years, the vast majority ($n = 28$, 80.0%) of the respondents declared an overall volume of >10 traumas, but only a minority ($n = 5$, 14.3%) treated >10 PED-PVIs. Most of the physicians ($n = 18$, 51.4%) treated <5 PVIs during the same period of time; 8 (22.9%) physicians declared no specific PVI experience. A large majority ($n = 14$, 40.0%) of respondents declared to use an age threshold of 15 years to start to commence an antithrombotic regimen after the revascularization for PVI. Figure 2 depicts the age threshold categories among the different respondents.

Choice of Antithrombotic Treatment

End-to-end anastomosis. We obtained 5 different antithrombotic regimens, aspirin alone being the most frequently used ($n = 15$, 42.9%) agent. Aspirin was also used in combination with low-molecular weight heparin (LWMH) by 9 (25.7%) additional physicians; therefore, the presence of aspirin as antithrombotic agent was used by 24 (68.6%) physicians, overall (Fig. 3). Only 1 (2.9%) respondent did not use a specific antithrombotic regimen postoperatively in this kind of scenario.

Short (<5 cm) interposition autologous graft. We obtained 7 different antithrombotic regimens, aspirin alone being the most frequently used ($n = 14$, 40.0%) agent. Aspirin was also used in combination with other agents by an additional 9 (25.7%) physicians: LWMH ($n = 8$, 22.9%) and LWMH plus oral anticoagulants ($n = 1$, 2.9%). In this subset of PVI, LWMH was used by 18 (51.4%) of the respondents, overall. Once again, no postoperative antithrombotic regimen was selected by only 1 (2.9%) respondent (Fig. 3).

Long (>5 cm) interposition autologous graft. In this subset of PVI, all respondents used 1 specific antithrombotic regimen at least. We obtained 6 different antithrombotic regimens aspirin alone being the most frequently used ($n = 13$, 37.1%) agent. Aspirin was also used in combination with other agents by an additional 10 (28.6%) physicians: LWMH ($n = 9$, 25.7%), and LWMH plus oral anticoagulants ($n = 1$, 2.9%). In this subset of PVI, LWMH was used by 19 (54.3%) of the respondents, overall. Once again, no postoperative antithrombotic regimen was selected by only 1 (2.9%) (Fig. 3).

Prosthetic interposition graft. Also, in this subset of PVI, all respondents used 1 specific antithrombotic regimen at least (Fig. 3). We obtained 11 different antithrombotic regimens, but aspirin alone was used less frequently than in the previous scenarios ($n = 6$, 17.1%). A combination of aspirin with other agents was used by 23 (65.7%), but also LWMH was used in combination with other agents with a similar frequency ($n = 22$, 62.8%). Oral anticoagulants or direct oral anticoagulants were used by 6 respondents (17.1%).

Duration of the Antithrombotic Treatment

There is a greater degree of homogeneity across the different scenarios in the duration of antithrombotic therapy compared with previous scenarios. The most frequently used period of time is 1 to 6 months ($n = 16$, 45.7%) in 3 of the 4 scenarios, such as end-to-end anastomosis and interposition grafts with autologous conduit (either short [<5 cm] or long [>5 cm] one). In the last scenario, namely PVI needing the use of a prosthetic graft for arterial reconstruction, there is equipoise between 2

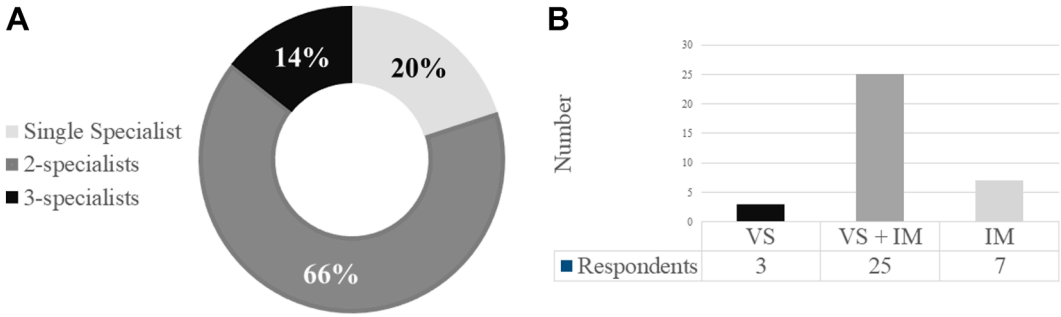

Fig. 1. (A) Distribution of the responders stratified by number of physicians in charge of the antithrombotic choice and **(B)** the combination of the disciplines inside the group. IM, internal medicine; VS, vascular surgeon.

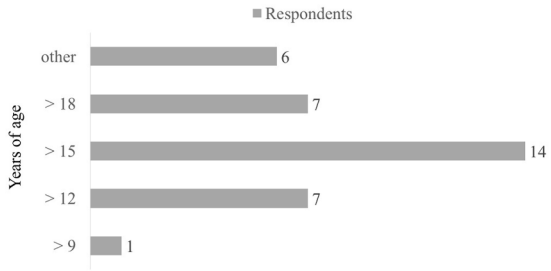

Fig. 2. Years of experience in the treatment of major vascular traumas in the pediatric population, declared by the respondents.

different schemes: 1 to 6 months (n = 13, 37.1%) and >12 months (n = 12, 34.3%).

Safety Monitoring and Follow-Up Considerations

Most of the respondents (n = 29, 82.9%) declared they have not observed severe bleeding complications using any specific antithrombotic regimen. Eventually severe bleeding would have been detected, most of them (n = 28, 80.0%) would have modified their antithrombotic regimen. When they were asked to describe the protocol for anticoagulation surveillance, we obtained 19 (54.3%) different schemes: blood counts plus international normalized ratio and activated partial thromboplastin time was the most frequently used (n = 12, 34.3%). As far as the follow-up surveillance is concerned, the presence of a ≥50% asymptomatic stenosis at an anastomotic site was a key question to evaluate a potential change of the antithrombotic regimen, with pretty different answers: in the end-to-end reconstruction, 13 (37.1%) would have not prompted any kind of changes, 12 (34.3%) would have judged based on different covariates (e.g., anastomotic site, age, collateralization), whereas 10 (28.6%) would have changed their therapeutic scheme by changing the drug agent (n = 9, 90.0%) or increasing the dosage (n = 1, 10%). After a short (<5 cm) interposition autologous graft, 13 (37.1%) would have changed their treatment, 11 (31.4%) would have not, and 11 (31.4%) would have judged based on different covariates. After a long (>5 cm) interposition autologous graft, 14 (40.0%) would have changed their treatment, 11 (31.4%) would have judged based on different covariates, whereas 10 (28.6%) would have not changed it. In the case of prosthetic reconstruction, 22 (62.8%) would not change the regimen whereas 13 (37.1%) changed it by selecting a different drug (n = 9) or increasing the dosage of the original one (n = 4).

DISCUSSION

Major pediatric PVI may belong to the same principal categories as adults, but have been poorly documented, owing to their overall rarity as well as the difficulty in conducting high-quality studies in the field.[16] The results of our survey demonstrate how, at least on a national level, not even the reference and/or high-volume centers for the treatment of vascular traumas are able to amass robust data for these scenarios: in fact, the vast majority (86%) of the centers declared to perform <10 PED-PVI cases per year.

One of the key pending matters when treating such injuries revolves around the selection of postoperative antithrombotic treatment in terms of drug, dose, and duration.[4,5,17–20] In this context, the latest European Society for Vascular Surgery 2025 Clinical Practice Guidelines on the Management of Vascular Trauma recommend that postoperative single antiplatelet therapy may be considered for patients with vascular trauma who

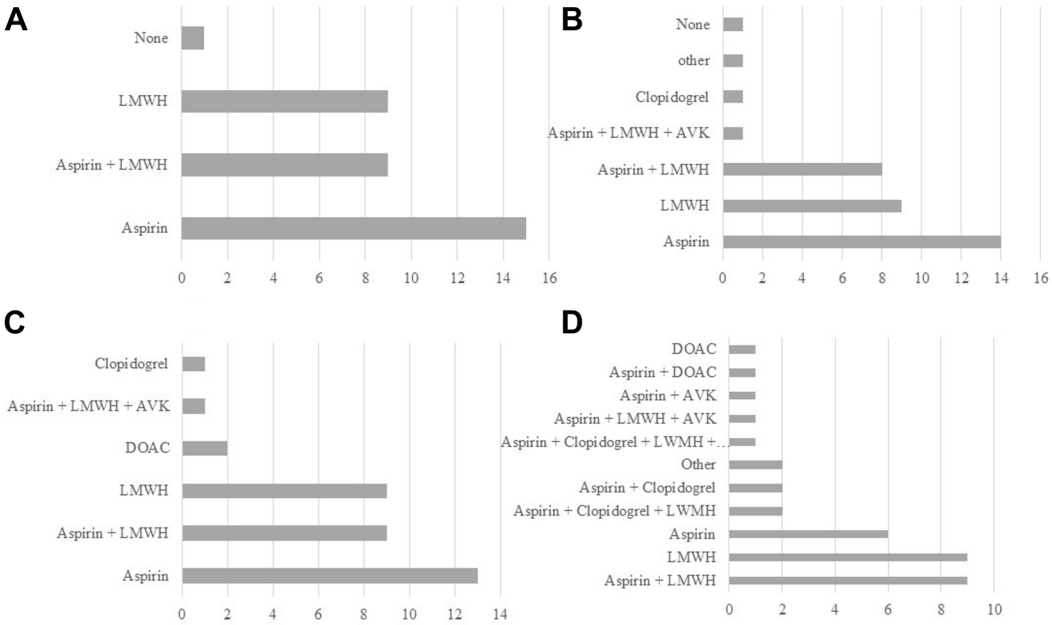

Fig. 3. Description of the different antithrombotic drug regimens stratified by the different scenarios: **(A)** end-to-end anastomosis, **(B)** short (<5 cm) autologous vein interposition, **(C)** long (≥5 cm) autologous vein interposition, and **(D)** prosthetic graft interposition. AVK, anti-vitamin K; DOAC, direct oral anticoagulants.

have undergone open or endovascular repair (recommendation 98; class IIB, level C).[2] However, this recommendation may not automatically apply to the pediatric population, as the same document recognizes that a standard protocol for antithrombotic therapy does not exist for pediatric patients after vascular trauma. In fact, several intertwined factors may play a role in decision-making including the age of the patient, the pattern of sustained injury, the type of repair performed, and the pharmacokinetic and pharmacodynamic profiles of any drug (or drug class). In the available pediatric patients' literature, recommendations have been generally extrapolated from adult experiences, being characterized by wide heterogeneity.[5,21,22] Hence, in our experience, it has not been surprising to observe that, although aspirin and LWMH were the most frequently used drug regimens, multiple drug associations were used, with wide heterogeneity among the different reconstructive scenarios. The results of our survey echoed the experience of Kirkilas et al.[4] who reported the use of multimodal regimens comprising heparin, aspirin, or enoxaparin for varying lengths of treatment was provided. Both experiences thus once again highlight the absence of clear recommendations for postoperative protocols. Indeed, the present survey conducted among a nationally representative panel of interdisciplinary experts (from fields including vascular surgery, pediatrics, and vascular medicine) details the practices endorsed at tertiary institutions, thereby creating the basis for future studies, and highlighting the need for dedicated centers that can best treat this challenging population.

By providing a series of detailed case-based scenarios, the current report has tried to provide a framework for identification of shared practice patterns among physicians actively involved in the management of major PED-PVI. Briefly, we found several areas of fair agreement but in general the more complex the scenario, the more heterogeneous was the spectrum of antithrombotic drug regimens adopted especially when comprising longer replacement or prosthetic grafts. The complexity of the approaches has also extended to surveillance period: there was homogeneous heterogeneity not only on the duration of the treatment adopted, but also on the coagulation controls where 19 different institutional schemes were described.

Data from the literature show that aspirin was the most prescribed outpatient regimen for pediatric patients with arterial injuries.[5,20] However, the major drawback of the use of acetylsalicylic acid is its theoretical contraindication in patients under the age of 16 due to the correlation with a rare but serious pediatric disease called Reye's syndrome.[21] Recently, choices for anticoagulation in children have expanded greatly with new agents showing

favorable efficacy and safety profiles compared with heparin and warfarin.[18] The efficacy and safety of antithrombotic therapies in children with thromboembolic disease has been recently evaluated by Gao et al.[20] in a network meta-analysis of 16 randomized controlled trials. In the prevention of thromboembolic events, the use of anticoagulants had a low risk of thromboembolic events and a high risk of minor bleeding compared with no anticoagulants. In the treatment of thromboembolisms, direct oral anticoagulants were not inferior to standard anticoagulation in terms of efficacy and safety outcomes. Therefore, these results may support the use of direct oral anticoagulants in children, although caution should be exercised as none of the included studies specifically include arterial events.

Producing high-quality evidence in the pediatric population is notoriously difficult, even more so for quite rare and often nonelective scenarios.[16] A recent review on the available evidence on barriers and facilitators to participating in pediatric clinical trials has identified the important roles of parental consent, preferences, attitudes, and experiences, as well as the need to involve children in the decision-making process when possible.[23] Parental consent depends on several factors: the severity of the disease, the complexity of the study, the perceived benefits, alternative therapeutic options, trust in medical professionals, and the sociodemographic status of the parents. Only through multidisciplinary and multicentric collaboration will it be possible to gather high-quality data that may ultimately benefit patients and their families. Regarding this last observation, our survey confirms the importance of the multidisciplinary approach. In fact, in contrast to the vast heterogeneity highlighted in our results, although the Vascular Surgeon was almost invariably in charge of selecting the antithrombotic regimen, frequently he was in conjunction with 1 or multiple other specialists.

Study Limitations

The present study has obvious limitations. First, the analysis is based on a cross-sectional survey, without a longitudinal perspective. Surveys have been increasingly adopted in recent years as they may provide an efficient and rapid way to provide fairly large volumes of data from broad audience, while offering both quantitative and qualitative insights into behavior, opinions, and attitudes. Given the geographical distribution from a single nation, it is likely that differences in health care settings may also lead to different interpretation of findings. Therefore, this study should be interpreted in light of its inherent limitations. Also, the small sample size may reduce the reproducibility of the results and therefore the quality of the study. Then, although our response rate was high (70%), it is still possible that pooling responses from physicians who did not participate in our survey could have slightly changed the results. Finally, although some practice patterns were identified, these solely represent the view of single experienced physicians but should not be seen as indicators of formal clinical consensus discussion. Furthermore, the way questions have been formulated, and the choice of measurement method may have impacted on the effectiveness and validity of the study, leading to biased or incomplete results.

CONCLUSION

The present survey shows that PED-PVI are also infrequently encountered in referral centers. Although aspirin usually is not given to children under 16 years of age, aspirin and LWMH are the most frequently used drugs after major PED-PVI reconstructions, and more frequently used in association. Although a multidisciplinary team evaluation is frequently adopted in referral centers, the vascular surgeon plays a major role in determining what antithrombotic drugs should be commenced after major PED-PVI reconstructions. A clear-cut heterogeneity was observed in this survey across the different questions and scenarios: this highlights the need for dedicated consensus statement document.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

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SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.avsg.2026.01.044.

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