Research Article

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The role of Rehabilitation in pediatric amputation – A 10-year retrospective study in a Portuguese population

Abstract

Introduction: Limb amputation in pediatric population, whether congenital or acquired, has a set of attributes that require a different medical approach and rehabilitation management.

Objectives: To characterize the pediatric population referred to the Amputee Rehabilitation consultation and evaluate amputation type and segment relationship with prosthesis usage.

Material and methods: We conducted a retrospective study based on the clinical information from patients referred to the Pediatric Rehabilitation consultation between January 2011 and March 2021. The variables analyzed included gender, type, and etiology of amputation, amputation level, age of prosthesis, time to the first prosthesis, pre-prosthetic training, number of components prescribed, waiting time per component, and prosthesis use.

Results: The study included 50 patients, 68% of congenital etiology. Within the group of acquired amputations, 62.5% had neoplastic causes. The initial use of a prosthesis occurred in 91.7% of the population with upper limb amputations. However, the final adhesion of the upper limb prosthesis was only 50%. There was a statistically significant dependence and a moderate association between the amputated segment and the final use of the prosthesis. The abandonment risk of upper limb prosthesis was seven times higher than lower limb prosthesis. The remaining variables did not demonstrate any other type of significant association.

Conclusion: In pediatric age, congenital amputations are more frequent than acquired causes. However, contrary to other data, malignancy was the most frequent etiology in this study within acquired amputations. Regardless of the type of amputation, the use of a prosthesis is related to the affected segment. The abandonment risk of upper limb prostheses is significant, given the development of compensatory strategies that allow the functional use of the limb. Physical and Rehabilitation Medicine plays an essential role in the assessment and management of pediatric amputation. Prescribing at the right time, carrying out an adequate program, with the child and family, is the key to their functional independence.

Keywords: amputation, limb deformities, pediatrics, rehabilitation, prosthesis fitting

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Introduction

Amputation in the pediatric population has a set of characteristics that must be treated differently compared to adults. In children, limb amputations can be congenital or acquired. Global epidemiological data show that congenital malformations are the leading cause of limb deficits in the first decade of life.[1] In Portugal, the prevalence of congenital limb malformations is 2.16 cases per 10,000 live births between 1980 and 2019.[2] Limb development occurs during the 4th and 8th gestation week. Most changes occur between the 4th and 6th when mesoderm differentiation and tissue proliferation peak occur.[1] Several molecular pathways are involved in limb differentiation. Errors in these pathways can be associated with these deficits, which are often undiagnosed. Genetic syndromes, vascular changes, exposure to teratogenic agents, or even amniotic bands are other possible etiologies. There are different amputation classification systems. In congenital deficits, the most used classification is the International Society for Prosthetics and Orthosis (ISPO) classification, which divides these deficits into transverse and longitudinal. A transverse deficit is defined when the absent segment is distal to the level described. A longitudinal deficit refers to the partial or total absence of skeletal elements along the longest axis of the limb, with the preservation of distal elements.[3] In acquired amputations, the terms used in the upper limb include shoulder disarticulation, transhumeral, elbow disarticulation, transradial, wrist disarticulation, and partial hand amputation. For lower limb amputations, the different levels are translumbar, transpelvic, hip disarticulation, transfemoral, knee disarticulation, transtibial, ankle disarticulation, and partial foot amputation.[4]

Congenital limb differences are much more frequent in the upper limb, especially transversal deficits.[1,5–7] In the lower limb, longitudinal finger deficits prevail. Despite prenatal ultrasound screening, congenital limb anomalies may go unnoticed.

In acquired amputations, trauma prevails, almost twice to other causes. The male gender is prevalent, with the fingers being the most affected segment. Mechanisms associated with traumatic amputation include car accidents, machinery accidents, or even crushing doors. Like other causes of acquired amputation, malignancy is an important cause to be mentioned. Osteosarcoma, Ewing's sarcoma, or rhabdomyosarcoma can result in amputation.[1,8,9]

This study aims to characterize the pediatric amputee population referred to the Pediatric Amputee Rehabilitation consultation, in terms of gender, amputation cause, time elapsed until prosthesis, use of prosthesis, and identifying the relationship between predisposing factors and prosthesis abandonment.

Material and methods

We conducted a retrospective study by accessing clinical information of patients referred to the Pediatric Amputee Rehabilitation consultation between January 2011 and March 2021. Demographic data, cause, and type of amputation were collected. To describe the type and level of amputation, we used the ISPO classification. Other information included the number of prostheses prescriptions, components prescribed, and respective time between prescription and delivery. Information from the last consultation based considered the use of prosthesis. We analyzed variable independence and association measures. For this purpose, patients were divided according to the etiology of the amputation and affected limb. We also compared the time between prescription and prosthesis/components delivery. A p-value <0.05 was considered statistically significant. Data analysis was performed with IBM SPSS® Statistics version 26.0.

Results

Between January 2011 and March 2021, 50 children were included in the study, 74% male and 26% female (Figure 1). Cause of amputation revealed 68% of congenital and 32% of acquired amputation (Figure 2). Within the latter, 62.5% had a neoplastic cause, 18.8% were traumatic, 12.5% were infectious, and 6.3% had a vascular cause (Figure 3). Considering the gender distribution by cause of amputation, 70.6% of children with congenital amputation were male and 29.4% female. In the acquired amputation group, 81.3% were male and 18.8% female. Concerning the distribution of amputated limbs, 58% of the population had lower-limb, 34% had upper-limb, and 8% had upper and lower limb amputation. The most frequent deficit was transversal (74%), even in the congenital amputation group (61.8%). In congenital deficits of the upper limb, the most frequent level was transverse radial. Congenital deficits of the lower limb were more frequently longitudinal tibial and fibular.

In acquired deficits, transfemoral amputation was the most frequent level. In cross-analysis of etiology and level of amputation, 58.6% of patients with lower limb amputation were congenital, and 41.4% were acquired. In patients with upper limb amputation, this percentage was 82.4% and 17.6% of congenital and acquired causes, respectively.

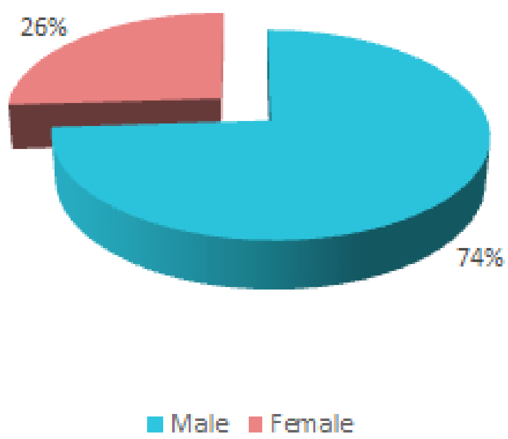

Figure 1 Gender distribution.

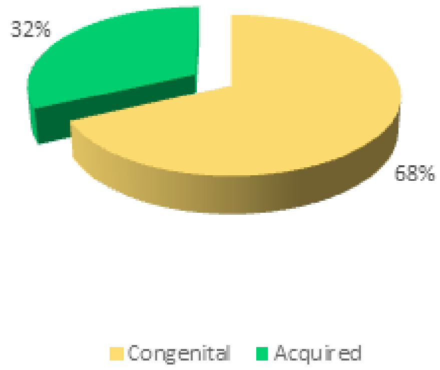

Figure 2 Distribution according to amputation type.

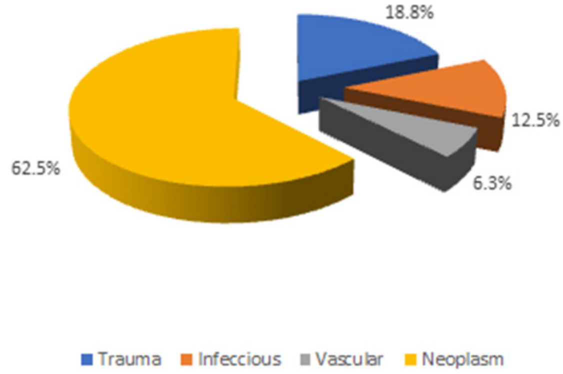

Figure 3 Causes of acquired amputation.

The majority of the children included met the criteria for prosthesis prescription (88%), 85.3% with congenital cause, and 93.8% with acquired cause, respectively. When considering limb amputation, 96.6% of children with lower limb and 70.6% with upper limb amputation met the same criteria for prosthesis prescription.

The average population age of prosthesis prescription was 4.1 years. For children with congenital amputation, the mean age was 1.9 years with a minimum of six months. For acquired amputation, eight years was the mean age, with a minimum of 1 year and a maximum of 16 years. Upper limb prosthesis prescription mean age was 1.2 years, with a minimum of 6 months and a maximum of 3 years. For the lower limb, the average age was 5.6 years, with a minimum of 6 months and a maximum of 16 years. Pre-prosthetic rehabilitation was conducted in 76% of children, 83.3% of the upper limb, 85.7% of lower limb amputations, in all subjects with acquired and in 78.6% of congenital amputation.

Initial prosthesis use occurred in 84% of the population, 96.4% congenital, and 93.8% with acquired cause. Furthermore, 91.7% of patients with upper limb and 96.4% with lower limb amputation were initially using a prosthesis.

According to information from the last consultation, prosthesis adhesion was 72% overall, 82.1% of patients in congenital and 81.3% in acquired etiology. Prosthesis adhesion in upper limb amputation patients was 50%, while in lower limb was 92.9%.

Regarding the number of components prescribed, there was an average of 5 components per patient, 5.9 and 3.6 in congenital and acquired causes throughout their follow-up, respectively. For upper-limb amputation patients, we observed an average of 3.4 components. For lower-limb amputation, the average of components prescribed was 5.6.

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The mean waiting time between prescription of the first prosthesis and delivery was 7.5 months. Upper-limb patients had a minimum of 2 months and a maximum of 1 year of waiting time for the first prosthesis. For the first lower limb prosthesis, the waiting time varied between 39 days and two years. The average waiting time between prescription and delivery, per prosthetic component, was about ten months, with a minimum of 4 months and a maximum of 2 years. In follow-up consultations, the average waiting time for upper limb prostheses was 8.6 months and ten months for lower limb prostheses.

Analysis of independence and association measures showed statistically significant dependence ($\chi2$ of 9.705; p = 0.002) and association (φ of 0.47; p = 0.002) between the affected limb and final use of the prosthesis. We obtained an adjusted residue value of 3.1 for the absence of current use of upper limb prosthesis. The relative risk of abandonment in upper-limb prosthesis was 7.07 relative to lower limb prosthesis. In the remaining analysis of independence and association, no other factors such as initial use of prosthesis, pre-prosthetic rehabilitation had statistically significant values with type of amputation or affected limb (Table 1).

Table 1 Measures of variables independence and association

Variable comparison	Chi-Square	p-value	Phi	p-value
Amputation Type – Initial use of prosthesis	0.168	0.682	0.062	0.682
Amputation Type – Final use of prosthesis	0.005	0.941	0.11	0.941
Pre-prosthetic rehabilitation – Initial use of prosthesis	0.331	0.565	0.087	0.565
Pre-prosthetic rehabilitation – Final use of prosthesis	0,011	0.918	0.016	0.918
Affected Limb – Initial use of prosthesis	0.649	0.723	0.121	0.723
Affected Limb – Final use of prosthesis	9.705	0.002	0.47	0.002

Discussion

Considering amputation causes, the study population corroborates current literature data, with congenital deficits being more frequently, mainly due to unknown causes. For acquired causes, the results do not agree with previous findings, as amputation due to malignancy was more frequent than traumatic amputation (62.5% vs. 18.8%). This difference may come from the population sample, as our pediatric oncology department is a national reference center for pediatric bone tumors. Improvements in diagnostic capacity may have an impact on the early detection of malignancy and prompt referral. On the other hand, awareness and accident prevention measures and changes in children's lifestyles may play a role in reducing traumatic causes.

Lower limb amputation was the most frequent in the overall population. However, congenital amputations affected mostly the upper limb (82.4%).

The age of prosthesis prescription must be associated with different milestones in a child's development. In the lower limb, this milestone consists of verticalization at 6 to 12 months of age. In the upper limb, it is sitting balance, between 3 and 9 months. For younger children with upper limb amputations, prosthetic use's objectives consist of facilitation of development, stimulation of bimanual tasks, crawling, toy manipulation, and verticalization. In the lower limb, the objective is to give and maintain walking capacity. In our study, the average waiting time for the first prosthesis follows the recommendations.

The child's growth requires frequent revision of the prosthesis. A lower limb prosthesis tends to be more subject to wear, thus explaining a higher average number of components prescription. Amputations of any cause at a younger age naturally result in a more significant number of revisions over time. The need for a new prosthesis is different depending on the child's age and growth rate. Children of younger age need more revisions, while at older ages, the interval increases.

Regardless of the cause of amputation, prosthesis use is related to the affected limb, particularly the upper limb. In our study, there was a decrease of 41.7% in the use of upper limb prostheses. In addition to being dependent, these variables showed a moderate association and an approximately 7-fold higher risk of abandonment compared to the use of lower limb prostheses. An upper limb prosthesis can be maintained if introduced at earlier ages and incorporated into the child's body scheme. However, stump superficial and deep sensitivity development, the respective loss with the use of a prosthesis, and the development of compensatory functional strategies (use of the residual limb, knee, or chin) allow the child to be as much functional with or without the prosthesis. Our study could not acquire information about the activities performed or the time length children wear prostheses.

By allowing the ability to walk independently, the abandonment risk of a lower limb prosthesis drastically reduces, most likely due to loss of functional capacity or associated complications.

Conclusion

The primary role of rehabilitation for pediatric amputations is to maintain children's participation. It is one of the leading indicators of functionality and, above all, quality of life.[6,10,11] However, having a prosthesis is not synonymous with improved participation. A prosthesis should allow a child to continue to be a child, allowing them to engage in daily games and activities, and acquire the skills necessary for normal development. If a prosthesis makes participation difficult or impossible, the best decision is not to conduct any prosthetization. Thus, performing a rigorous clinical and functional evaluation with validated instruments is essential to weigh the clinical and functional benefits.[7] Clinical evaluation should also address the child's environment, both at home and school, family relations, expectations, and self-perception image.[1,6,11] Rehabilitation never works alone. Amputee children can have different types of medical complications that can be difficult to manage. It is crucial to consider the impact that different decisions may have during childhood and transition to adulthood. The interaction of medical and non-medical staff in a multidisciplinary/interdisciplinary way, working together with the children and their families, allows them to have a whole and successful life.[1,6,7]

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Conflicts of interest

The authors have no conflicts of interest to declare.

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None.

Author contributions

All authors contributed to the development of this article according to the ICMJE Criteria for Authorship.

Data availability statement

All data generated or analyzed during this study are included in this article and its supplementary material files. Further enquiries can be directed to the corresponding author.

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