

## Original paper

# The impact of endovascular intervention and open surgery on the incidence of lower extremity amputations

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### Summary

**Objectives:** The impact of endovascular surgery on the amputation rate is not clearly determined. The study aims at determining the relationship between the increasing number of endovascular procedures and the incidence of the lower limb amputations.

**Patients and methods:** Annual reports comprising 78,250 cases of peripheral arterial disease (PAD) obtained from 8 Lithuanian vascular surgery centers in 2001–2009 were overviewed and analyzed. There were 7,070 procedures of percutaneous transluminal angioplasty (PTA), 31,488 arterial reconstructive operations and 5,340 amputations of the lower limb.

**Results:** The number of amputations performed in 2009 increased by 7.4% compared to 2001. In this period the number of patients treated by vascular surgeons increased by 1,748 (22.3%). The number of reconstructive vascular operations remained relatively stable: 3,468 in 2003 compared to 3,376 in 2009. Endovascular procedures performed from 2001 to 2009 increased by 1,277 (309.2%). A strong correlation between the number of patients treated and the growing number of PTA in 2001–2009 was observed ( $r = 0.916$ ,  $p = 0.001$ ). An expansion of endovascular treatment resulted in decreasing number of amputations ( $r = -0.754$ ,  $p < 0.01$ ). The linear regression analysis showed that the increase in PTA by 1% resulted in decline of amputation number by 0.77% ( $p = 0.001$ ).

**Conclusions:** Amputation rate is reliant on changes of admissions for critical limb ischemia. With the increasing number of endovascular procedures, amputation rate is decreasing.

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**Keywords:** Peripheral artery atherosclerosis, endovascular surgery, reconstructive arterial surgery, amputation

### Introduction

Despite increasing revascularization possibilities the lower extremity amputation remains a common practice in today's vascular surgery [1]. The absolute majority of all lower limb amputations are being performed for critical limb ischemia (CLI) [2–4]. CLI comprises the major part of vascular surgery unit workload. According to some literature sources CLI has been the cause in 86% of all amputations performed in vascular surgery institutions in the last 15 years. Of them 35% were primary amputations [5]. It is es-

timated that the approximate incidence of CLI is 50–100 cases per 100,000 of population per year, and it increases because of aging population [6]. In the US about 80,000 major amputations (above the ankle) are being performed annually [7,8] (24/100,000 inhabitants). The comparable data are presented by European statistics [9–12].

Revascularization of the lower limb can be performed by reconstructive arterial surgery or by an endovascular procedure. In patients with peripheral arterial disease (PAD) the most common methods of revascularization are venous or prosthetic bypass, endarterectomy and PTA with or without stenting [1]. The most frequent causes of open surgery denial are concomitant diseases, advanced age or diffuse character of occlusive arterial disease. Patients who have been deprived of surgery are under constant threat of amputation.

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It is likely that endovascular treatment in lower limb ischemia can help in many cases where arterial reconstruction is inapplicable. The role of endovascular surgery in saving the lower limbs could be judged by the changes in amputation rate for patients with CLI. However there is no evidence in the literature that PTA or stenting have significantly decreased amputation rate and improved the possibilities to save ischemic limbs.

The exact data on the lower extremity amputations and their causes are not available at the Lithuanian Department of Statistics. Furthermore, the influence of changing and improving revascularization methods on amputation rate remains obscure.

The aim of this study was to evaluate the changes in the lower extremity amputation rate in relation with significant expansion of endovascular surgery in Lithuanian vascular surgery institutions and of its essential influence with the treatment methods of CLI.

## Patients and methods

Annual reports comprising 78,250 cases of peripheral occlusive arterial disease (PAOD) obtained from eight Lithuanian vascular surgery centers in 2001–2009 were overviewed and analyzed. There were 7,070 procedures of percutaneous transluminal angioplasty (PTA), 31,488 arterial reconstructive operations and 5,340 amputations of the lower limb.

The reports included anatomical characteristic of occlusive process in the aorta and peripheral arteries, the number of elective arterial reconstructions, operations for acute lower limb ischemia and amputations. They also reflected the major complications, mortality and the causes of death. The type of endovascular procedure and the arteries treated were presented in

these reports as well. The data were collected from 1 January 2001 to 31 December 2009.

## Statistics

The statistical analysis was performed using MS Excel 2007, SPSS 17.0, STATA 11 programmes. The chi-square, Fisher, Pearson correlation, ANOVA tests, linear regression analysis methods were applied. The results are considered significant when  $p < 0.05$ .  $r$  – rank correlation coefficient, which measures the extent to which, as one variable increases, the other variable tends to increase or decrease.

## Results

Since 2001 until 2007 the number of amputations for limb ischemia remained unchanged. In the period from 2008 to 2009 – an insignificant increase in amputation rate was observed (Table 1).

The rate of amputations in 2009 as compared with 2001 increased by 7.4%. Over the same period the number of patients treated in vascular surgery institutions increased by 1,748 (22.3%). Reconstructive vascular operations in the period from 2003 to 2009 remained stable: 3,468 in 2003 as against 3,376 in 2009. The number of endovascular procedures performed from 2001 to 2009 increased by 1,277 or 309.2% (more than 4 times).

The increase in PTA procedures by 1% was associated with a 0.77% decrease in the number of amputations in the same period ( $p < 0.01$ ). The regressive analysis showed that increase in PTA number by 1% was followed by 0.77% reduce in amputation rate ( $p = 0.001$ ).

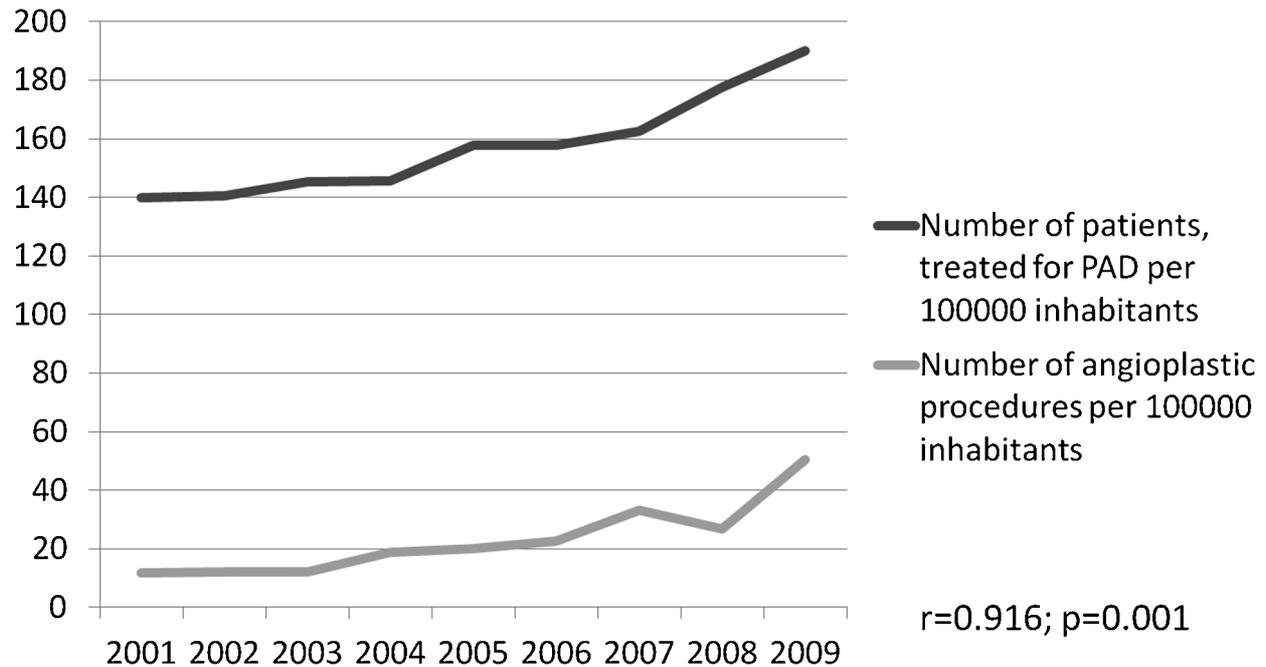
There was a strong correlation between the increase in the number of admissions and the PTA in 2001–2009 ( $r = 0.916$ ,  $p = 0.001$ ) (Figure 1).

A correlation between the number of admissions and the change in the number of amputa-

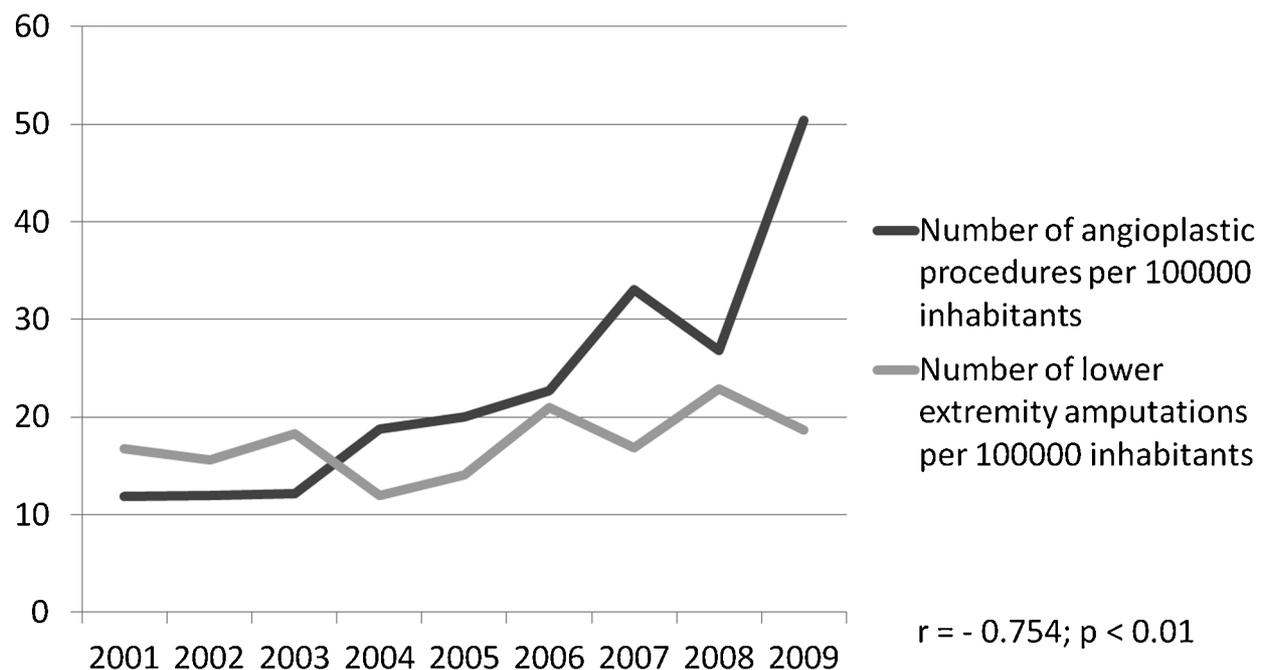
**Table 1.**  
Patients and methods of treatment from 2001 to 2009 in Lithuanian vascular surgery units

Year	Number of treated patients	Reconstructions	PTA	Amputations
2001	7853	2724	413	584
2002	8121	2979	417	542
2003	8361	3468	422	632
2004	8372	3694	648	414
2005	9033	3496	685	482
2006	8702	4279	773	715
2007	8956	3659	1120	572
2008	9251	3813	902	772
2009	9601	3376	1690	627

Note: PTA – percutaneous transluminal angioplasty.



**Figure 1.** The increasing numbers of patients treated for peripheral arterial disease (PAD) and angioplasty procedures in 2001–2009.



**Figure 2.** The increasing number of patients treated for PAD and variation of the incidence of amputations in 2001–2009.

tions also was evident ( $r = 0.534$ ,  $p = 0.069$ ) (Figure 2).

A significant negative correlation between the number of PTA procedures and the changes in the number of amputations was present ( $r = -0.754$ ,  $p < 0.01$ ). Yet, no relevant negative correlation between the growth in arterial reconstructive operations and the number of amputations was found (Figure 3).

The linear regressive analysis shows that the increase in PTA procedures by 1% results in the decrease of amputations by 0.77% ( $p = 0.001$ ).

### Discussion

Despite the advance in vascular medicine the number of amputations remains a significant problem worldwide. Limb loss rate in the de-

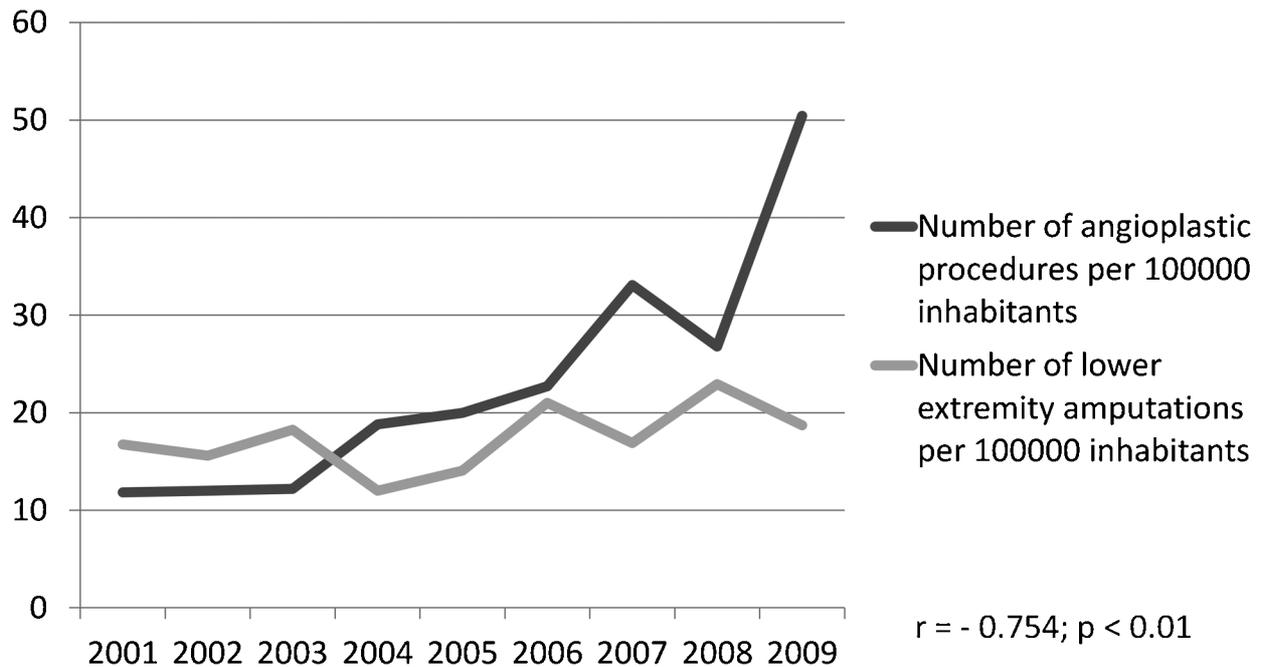


Figure 3. Negative correlation between angioplasty procedures and the incidence of amputations.

veloped countries is not decreasing [7–9]. Supposedly, it is related to the aging population, the growing incidence of diabetes mellitus, more frequent manifestation of peripheral arterial disease and smoking. The question arises whether the progress in blood flow restoring technologies is of any importance in altering the amount of the lower limb amputations. An inverse correlation between arterial reconstructive operations and amputations was evident in some centers of vascular surgery. Over the past 10 years, following the findings in Mayo Clinic, a 50% fall in amputation rate was unarguably related to the increase in the lower extremity revascularisation procedures including endovascular methods [13]. Similar results were presented in Europe. In England a 47% decrease in major amputations in the period of 1997–2000 was recorded [14–16]. However, another study in this country has shown no evidence of major amputations decrease in 2003–2008 [17].

The present study has shown that amputation rate increased in Lithuania by 7.4% over the last 9 years. What interpretation of the changes in the amputation incidence could follow? Having in mind that the volume of admissions for peripheral arterial occlusive disease enlarged by 22.3%, it was naturally enough to expect the proportional increase of the limb loss rate. Due to such factors as the aging population, the increasing prevalence of diabetes, inability to significantly reduce tobacco use, the number of amputations could be even higher [18,19]. Actually there is a discrepancy between increase of amputation rate and growing admissions of vascular patients. This

discrepancy can be explained by interfere of endovascular treatment with the limb salvage methods. As the results of present investigation have demonstrated, the frequency of PTA increased 4 times in the period of the last 9 years. That gives reasons for the statement that a large part of patients with CLI avoided amputations on the account of successful appliance of endovascular procedures.

The volume of reconstructive vascular surgery remained stable in Lithuania from 2003 to 2009, therefore surgical factor was not likely to have any significant influence on the incidence of amputations.

The effectiveness of endovascular treatment in reducing the number of amputations is confirmed by other authors. In some British studies the number of primary and secondary amputations is decreased due to a gradual increase in the number of endovascular procedures [20,21]. Other institutions presented the decrease of amputations by 70 percent in relation with endovascular surgery volume [22].

Although this positive impact may be true of the big centers with well-developed vascular service, the reports indicate that the incidence of amputations in some countries, regionally or nationwide does not decrease in parallel with the increasing workload of vascular and endovascular surgery [23–25]. In Maryland, the US, over 10 years, the rate of percutaneous angioplasty increased 24 times, and peripheral bypass surgery – 2 times, but it did not affect the overall rate of amputations in the state [26].

**Table 2.**

The incidences of lower limb amputations for critical ischemia in Lithuania and the world

Author	Country	Lower extremity amputations per 100,000 inhabitants	Year / period
Trautner [10]	Germany	31	2005
CDC Monthly Report [9]	USA	24	2005
Moxey [17]	Great Britain	11.4	2003–2008
Data from all Lithuanian vascular surgery units	Lithuania	17.3	2001–2009

The average incidence of amputations for critical limb ischemia in Lithuanian vascular surgery institutions is 17.3 cases per 100,000 inhabitants. It is higher than in the USA and Great Britain [9, 10,27] (Table 2). According to a study in the US, one of the causes for not decreasing limb loss rate is undoubtedly belated consultation of a vascular surgeon. The time span from the first signs of the foot necrosis to the seeing vascular surgeon was 73 days [1]. This example shows that the problem of the lower extremity amputation should be investigated considering not only the influence of treatment methods but also of health service organization.

## Conclusions

1. Amputation rate is reliant on changes of admissions for critical limb ischemia.
2. With the increasing number of endovascular procedures, amputation rate is decreasing.

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