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Original paper

Exsanguination of the limbs in elderly volunteers

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Abstract. We have evaluated the efficiency of exsanguination of the limbs in ten volunteers with a median age of 83 (range 76-86) years using Esmarch bandage or simple elevation. Changes in blood volume were evaluated using a scintigraphic technique based on an autologous injection of 99 mTc-labelled erythrocytes. In both upper (P<0.001) and lower (P<0.001) limbs, Esmarch bandage was significantly more effective than elevation. In lower limbs, there was a significant difference in reduction of blood volume between 5 s and 15 s of elevation (P<0.02).

Résumé. Nous avons évalué l'efficacité de l'exsanguination des membres chez 10 volontaires ayant un âge médian de 83 ans (76-86) en utilisant la bande d' Esmarch ou une élévation simple. Les changements volumétriques du sang ont été évalués par une technique scintigraphique basée sur une injection d'érythrocytes autologues marqués au Tc m 99. Dans les membres supérieurs (P<0.001) et inférieurs (P<0.001) le bande Esmarch était nettement plus efficace que l'élévation. Dans les membres inférieurs il y avait une différence importante dans la réduction du volume sanguin entre 5 et 15 secondes d'élévation (P<0.02).

Introduction

To obtain a bloodless field during limb surgery, a tourniquet is used. Before inflation of the tourniquet, an exsanguination procedure is performed to reduce the amount of blood in the limb. In recent studies, we have compared different exsanguination procedures for the lower [*3, 4*] and the upper [*3*] limbs in healthy young volunteers using a scintigraphic method [*2*]. We found that external methods were more

effective than elevation. However, when using elevation alone, we found that only 30 s were required, though we did not examine for periods shorter than 30 s. In the study of the upper limbs, we included shorter periods of elevation and found that only 5 s were required. At least for the younger patients, these findings are of practical importance, but we did not know if the results applied to elderly patients as well. Theoretically, the time needed for exsanguination should be longer in elderly subjects as a result of age-dependent changes in viscoelasticity of tissue affecting venous compliance responses [*9*].

In this study, therefore, we evaluated exsanguination of limbs in older individuals and compared results with those obtained from younger individuals.

Material and methods

Ten volunteers - six women and four men with a median age of 83 (range 75-86) years - participated in the study. One woman discharged herself from the lower limb examination because of too much pain from the tourniquet. All had palpable peripheral pulses in the examined right limb. No volunteer had a history of venous or arterial limb diseases, cardiac diseases, or cancer. No subject received medicaments apart from acetylsalicylic acid. No subject had major limb surgery. Total fat mass was measured with dual-energy X-ray absorptiometry (DXA-scan) (XR-36, Norland Medical Systems Inc., Fort Atkinson, Wis., USA). The local committee of ethics approved the study and subjects gave a written informed consent.

The method for evaluating changes in blood volumes was based on the autologous injection of 99 mTc-radiolabelled erythrocytes and use of a pneumatic tourniquet [*2*]. The gamma camera and positioning procedures for both upper and lower limbs were similar to methods used in previous studies [*3, 4*]. Each subject was placed supine with the leg or arm on a gamma camera. A 1-min scintigram of the lower leg and foot or the forearm and hand was obtained before and after the exsanguination procedure. In order to have a reproducible positioning of a region of interest (ROI) for subsequent integration of radioactivity, a 57Co source was placed 5 cm distal to the proximal demarcation of the right tibia and 3 cm distal to the right medial humeral epicondyle. As ROI, we used the smallest rectangle that included the right foot and part of right lower leg, or the right hand and part of right forearm, distal to the marking. Examples of scintigram appear from Figs. 1 and 2. The percentage reduction of blood volume was calculated from counts obtained before and after the exsanguination.

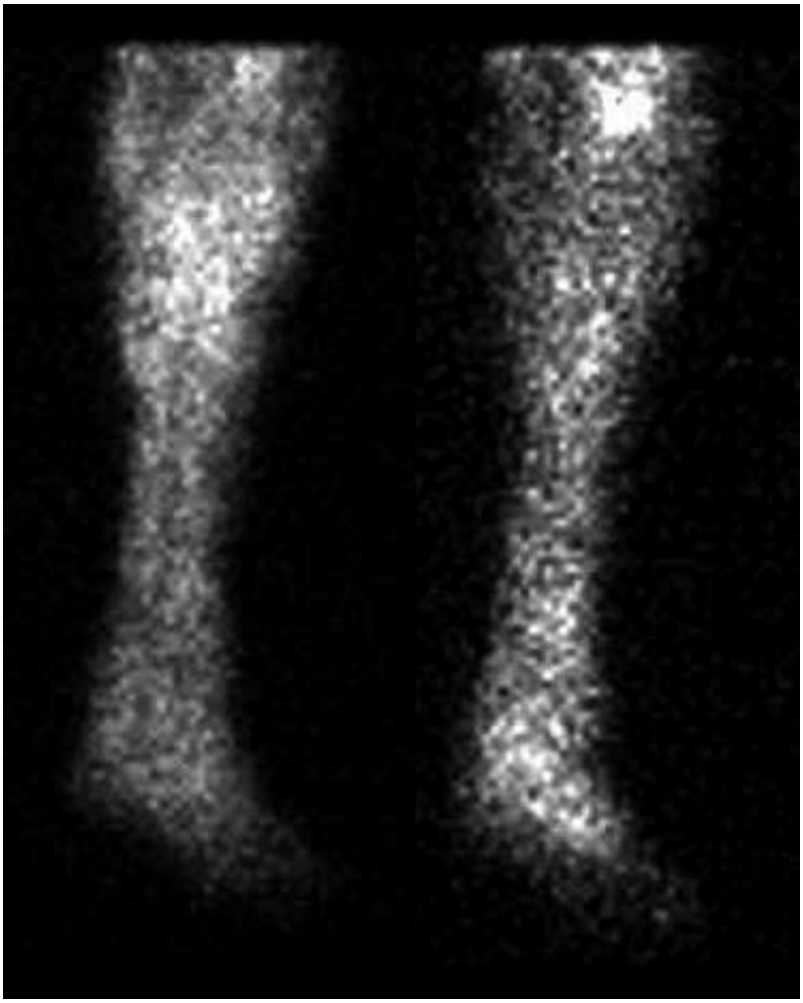

Fig. 1. One-minute scintigrams of the right lower limb of an 86-year-old man. The limb is shown before and after exsanguination using 15 s of elevation. The percentage reduction of blood volume after exsanguination was 47%

Fig. 2. One-minute scintigrams of the right upper limb of an 83-year-old woman. The limb is shown before and after exsanguination using Esmarch bandage. The percentage reduction of blood volume after exsanguination was 56%

The following types of exsanguination procedures were tested: Elevation alone, and Esmarch bandage. For the elevation procedure, the examiner elevated the leg to 60° and the arm to a vertical position for 5 s, 15 s, 30 s, 60 s, and 120 s. After the exsanguination procedure, a 14-cm wide pneumatic cuff mounted on the limb was inflated in a few seconds to a systolic arm pressure +150 mmHg on the leg and +100 mmHg on the arm [*10*]. After the cuff was inflated, the limb was instantly realigned on the gamma camera and a 1-min scintigram was obtained.

The tourniquet was then deflated. In order to secure that the hyperaemia phase had finished, five 1-min scintigrams were obtained before the next exsanguination procedure. The various exsanguination procedures were applied in random order using the drawing lot principle. In half of the cases, the arm was examined before the leg and vice versa.

In order to reveal correlations between age and blood volume reduction in the limbs, data obtained from previous studies of 22 individuals with a median age of 27 (range 20-39) years where incorporated in the analyses [*3, 4*].

Statistics

Friedman’s test and Wilcoxon matched pair test were used to compare results obtained from different exsanguination procedures. Kendall rank correlation coefficient test was used to reveal a relationship between the percentage reductions of blood volumes and age. A value of $P<0.05$ was considered significant in all tests, which were performed as two-tailed.

Results

Results of the different exsanguination procedures in the lower and the upper limbs are given in Figs. 3 and 4, respectively. With regard to elevation results, a significant difference was found between 5 s and 15 s of elevation of the lower limb ($P<0.01$). In elevation of the upper limb, no significant difference was found. Esmarch bandage was significantly more effective than elevation in both lower ($P<0.001$) and upper ($P<0.001$) limb. With respect to elevation alone, the lower limb was significantly ($P<0.02$) more exsanguinated than the upper limb, whereas no significant difference was found using the Esmarch bandage.

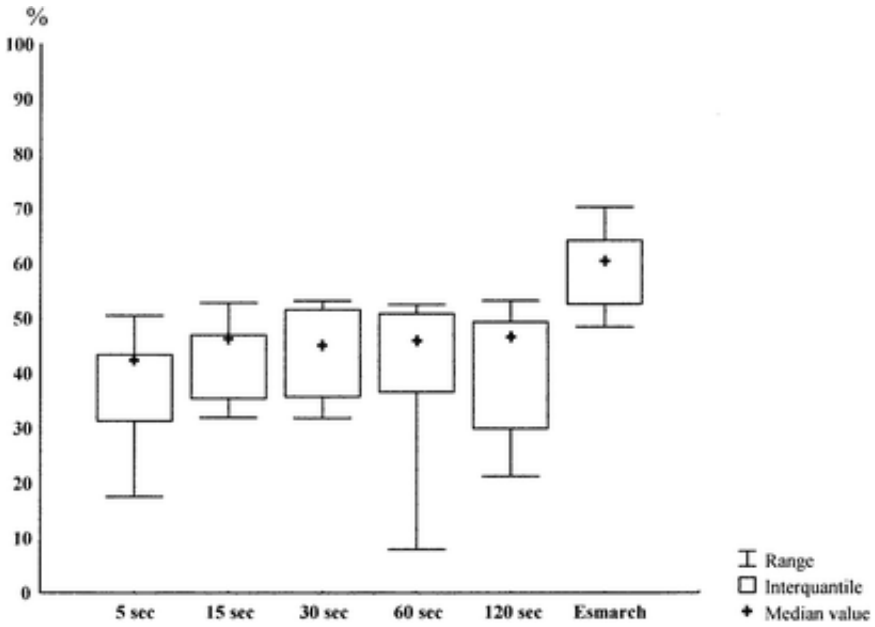

Fig. 3. Mean percentage reduction of blood volume in the lower limb before and after elevation for 5, 15, 30, 60 and 120 s, and before and after using Esmarch bandage (*n*=9)

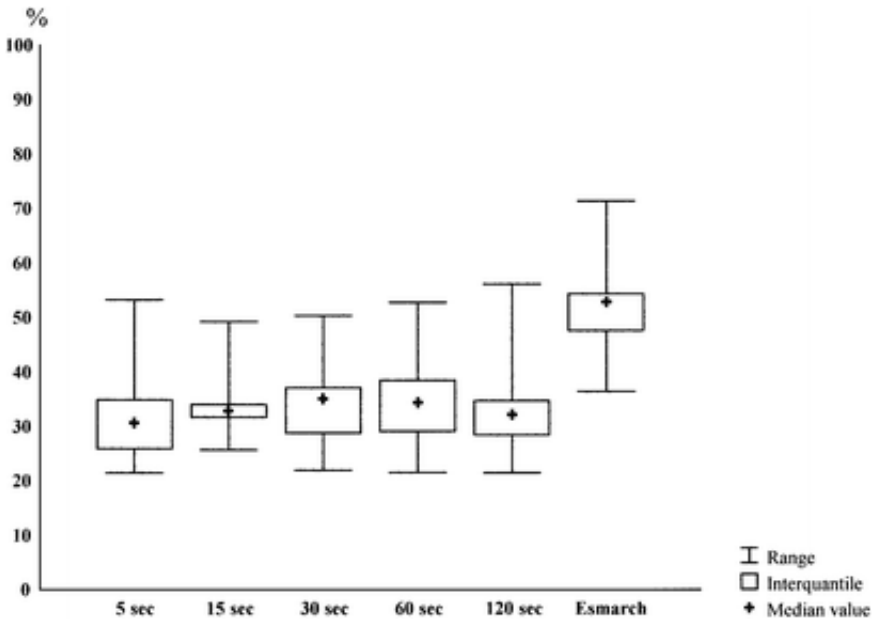

Fig. 4. Mean percentage reduction of blood volume in the upper limb before and after elevation for 5, 15, 30, 60 and 120 s, and before and after using Esmarch bandage (n=10)

After having included results from the young individuals, no significant correlation between age and the percentage reduction of blood volume in either upper or lower limbs was found.

Discussion

Unexpectedly, and in contrast to some previous studies dealing with age-dependent changes of the venous physiology [*5*, *6*, *7*, *9*], we found no correlation between the result of exsanguination and age. The reason for the divergence between our results and previous studies can be explained by differences in the methods applied and topic focus.

Regarding elevation alone, we found that 15 s of elevation is needed when the lower limb has to be exsanguinated, whereas only 5 s is needed for the upper limb. This agrees with result obtained in younger individuals. However, in the previous lower limb study [*3*, *4*], we unfortunately did not test elevation periods shorter than 30 s. We have, however, no reason to assume that results from older individuals cannot be applied to younger individuals.

In this study, we tested exsanguination by elevation alone and by Esmarch bandage. We did not include other external methods, as this would have caused an unreasonably long experimental time for each individual, with the subsequent risk of poor compliance. The Esmarch bandage was chosen because it is the most effective of the external methods (gauze bandage, Pomidor roll cuff, squeeze method, Urias bag).

It must be remembered that the application of the Esmarch bandage is time consuming, auto-clavation is troublesome [*1*, *8*], and both the Esmarch and the gauze bandage may be contraindicated if a fracture is present or if the skin is fragile. Furthermore, Esmarch bandage in an animal study has been shown to activate platelets [*11*]. The Urias bag is impractical and ineffective. The squeeze method [*3*], though it is not as effective as other external methods, has been found to be the method of choice in young healthy subjects because it is fast, practical, and inexpensive. However, since in this study we

found no major physiological differences between young and elderly subjects with respect to exsanguination, we believe this also is applicable to the elderly.

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