The Supply of Blood in the Skin Territory Above The Lower Part of the Serratus Anterior Muscle

Running title: Skin Blood Supply over the Serratus Anterior Muscle

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ABSTRACT

At present, the putative clinical use of the musculocutaneous and ostomusculocutaneous serratus anterior flaps has been compromised by the risk of partial or total necrosis of the skin overlying the lower part of the serratus anterior muscle. Therefore, the aim of this study was to delineate a skin area vascularized by perforant musculocutaneous branches of arteries stemming from the lower segment of the anterior serrated muscle. Black ink was injected in thoracodorsal artery branches for the serratus anterior muscle in 50 human cadavers before the autopsies (the study was approved by the Institutional Review Board). The surface area of the labeled skin was determined and its borders delineated by means of transparent millimeter grid. Planimetry data were subsequently analyzed with the aid of PC computer program. The results show that the calculated mean surface area (143.79 +/- 2.68 x (2.077); range 138.22 cm^2-149.36cm^2) of the skin vascularized by perforant musculocuaneous branches stemming from the lower segment of the anterior serrated muscle, can serve as a reliable guide for taking serratus anterior flap in any patient. Therefore, appropriately sized musculocutaneous or osteomusculocutaneous serratus anterior flap can be safely and efficiently used in plastic and reconstructive surgery.

Key words: serratus anterior flap, skin island, musculocutaneous perforators, microsurgery

INTRODUCTION

The surgeons' desire to use the serratus anterior muscle in reconstructive surgical procedures as much as possible is limited because the area of the skin that can be lifted together with the muscle and/or the muscle and the bone segment, the front part of the ribs, in the process of shaping the serratus anterior flap, is unknown [1-15] .

The same problem is mentioned in all the studies that describe the use of serratus anterior flap in plastic and reconstructive surgery. Due to frequent partial or complete necrosis of the skin island over the lifted muscle, the serratus anterior flap is most commonly used as a muscle or muscle-bone graft without the accompanying skin cover[16-20] .

According to the research conducted by Taylor and Palmer the vascular territory of the skin over the serratus anterior muscle is formed as a juncture of the angiosomes of the lateral thoracic, thoracodorsal and the internal thoracic artery. The exact area of the skin that receives blood by way of the musculocutaneous perforators of the lower part of the serratus anterior muscle is unknown [4-15].

It was the above mentioned anatomical and clinical reasons that prompted us to conduct an anatomical research of the blood supply of this specific territory of the skin.

MATERIAL AND METHODS

Our research was conducted at the Institute of Anatomy „Drago Perović“, the Institute of General Pathology and Pathological Anatomy of the Medical School at the University of Zagreb and the Department for Plastic and Reconstructive Surgery at the University Clinic of Surgery, Clinical Hospital Center Zagreb.

The research was conducted on 50 cadavers prior to the autopsy with the approval of the Ethics Commission of the Medical School.

The research consisted of isolating the thoracodorsal artery and vein, injecting ink into the thoracodorsal artery above the branching point for the lower part of the serratus anterior muscle, and measuring the colored area of the skin vascularized by the musculocutaneous perforators of the lower part of the serratus anterior muscle (Figure 1).

After the cadaver was placed laterally on the autopsy table and the brachium was completely abducted with the front margin of the latissimus dorsi muscle visualized, a 10 centimeter incision was made three centimeters from the center of the skin fold of the armpit along the front margin of the latissimus dorsi muscle, and the thoracodorsal artery and vein, as well as the accompanying nerve, were visualized. Using microsurgical instruments the above mentioned vascular structures were isolated and the metal clamp placed on the thoracodorsal artery branch for the latissimus dorsi muscle. The thoracodorsal artery was cut four centimeters above the branching point for the lower part of the serratus anterior muscle, a one millimeter-inner-diameter plastic tube attached to syringe was inserted in the artery and 40 milliliters of black ink were injected. Once the coloration was observed, the area of the skin that receives blood by way of the musculocutaneous perforators of the lower part of the serratus anterior muscle was measured (Figure 2). The maximum skin area showing coloration was established once no change occurred following additional injection of black ink, that is, the size of the already colored area of the skin did not change. Transparent graph paper was than placed on the skin area showing coloration and the exact area delineated. After the procedure was completed, the plastic tube was removed and the incision closed with intradermal suture.

The results obtained on 50 graph paper sheets were computer analyzed and the area of the colored skin calculated employing the computer-assisted planimetric method (Figure 3). Microsoft Excel 4.0.a. was used for statistical analysis of the data.

RESULTS

The results of our research are shown in Figure 4. The statistical data analysis showed the largest and the smallest measured skin area of skin showing coloration in the sample, the range, the arithmetic mean, the standard error in the arithmetic mean, the median, the standard deviation, and the probability coefficient.

The largest measured area of skin showing coloration in the sample was 211.40 cm^2, and the smallest 131.83 cm^2. The range in the sample was 79.60, the arithmetic mean 143.79, the standard error in the arithmetic mean 2.077, the median 139.90, the standard deviation 14.70, and the probability coefficient 10.21.

The analysis of the results obtained by the statistical analysis shows that there is 99 percent probability of the mean value of the area of the skin that receives blood by way of the musculocutaneous perforators of the lower part of the serratus anterior muscle being within 143.79+/-2.68 x 2.077 interval, that is, between 138.22 cm^2 and 149.36 cm^2.

DISCUSSION

In our research, we applied the injection method to show the extent of blood supply in the skin as did Taylor, McGregor, Cormack, Lamberty, Rees, Timmons and Corlett[1-16]. The injected ink travels through the artery supplying blood to a certain area through musculocutaneous or fasciocutaneous perforators to the skin, just as blood does, and shows coloration on the skin surface. In this way, the area of the skin to

which blood is supplied by the feeding artery or by perforators becomes visible and is easily interpreted. The above mentioned studies report various types of colorants that can be used in skin perfusion studies, such as black, dark blue and red ink, methylene blue and Indian ink[1-16.]. In our research preceding this study we used Indian ink, methylene blue and black ink. In the process of injecting Indian ink, we noted powerful resistance to injection, which we attributed to the greater density of the Indian ink in comparison to the density of the other two colorants.

Although the coloration of the skin cover was satisfactory, we had to apply greater force while injecting because of the mentioned resistance, tearing the fragile artery wall in two cases, and damaging the inner layer of the blood vessel due to rough handling of the syringe to which the plastic tube was attached in three cases.

Methylene blue traveled through the blood vessels without any resistance, but the coloration of the skin was rather pale (light blue), providing no guarantee that the area of the skin supplied by blood will be clearly shown.

Black ink proved to be the most satisfactory and was therefore chosen as the basic colorant for showing the extent of blood supply in the skin in our study, as Taylor, Palmer and Cormack also used in their research[4-14].

While injecting, no resistance was noted, which facilitated gentle operation with the syringe, and the color that appeared on the surface of the skin was intense enough to make it possible for us to clearly delineate the colored area, which is the area of the skin supplied by blood.

We used 40 milliliters per sample, the same quantity used by Taylor, Cormack, Lamberty and Palmer[4-14].

In order to ensure that 40 milliliters of colorant were sufficient to show the area of the skin supplied by blood over the lower segment of the serratus anterior muscle, in our

preliminary research we injected the same quantity of black ink twice to observe whether the area of skin showing coloration would increase. We noticed no change in the area of the skin showing coloration in any of the twenty samples in our preliminary experiments following the second injection.

Following our research standard autopsy was conducted on each of the cadavers. While opening the thoracic wall we found black ink in the intercostal arteries, the internal mammary artery and the internal thoracic artery, which are the blood vessels that anastomose with the system of the thoracodorsal artery supplying blood to the lower part of serratus anterior muscle.

This finding clearly shows that the colorant travels in the direction of the lowest resistance, following into all the branches of the arteries that anastomose with the branches of the artery into which the colorant had been injected, through so-called choke connections through the border between the two neighboring skin territories. [6-11].

In measuring the area of the skin showing coloration on the cadavers, we employed the reliable planimetric method, as described in literature, with the aid of transparent millimeter graph paper which we pressed onto the colored area[4-11].

The computer-processed diagrams, that is, the drawings on the millimeter graph paper, show a black line tracing the outline of a gray irregular plane figure. The inner margin of the black line represents the border of the area of the skin showing coloration. By adding up the square centimeters (millimeters) on the transparent millimeter graph paper it is possible to accurately determine the area.

The computer-processed drawings of the areas obtained facilitate a more plastic description of the researched skin area, that is, an acceptable graphical representation of the skin area.

We would particularly like to emphasize that the computer planimetric method facilitates accurate delineation of the colored area and hence accurate determination of the irregular plane figures.

Figure 4 contains the values of the areas of the skin below the lower part of the serratus anterior muscle showing coloration following the injection of black ink in the thoracodorsal artery branch for the lower part of the serratus anterior muscle.

The area of skin showing coloration shows the territory of the skin to which blood is supplied by the musculocutaneous perforators of the lower part of the serratus anterior muscle.

The largest measured area was 211.40 cm^2, and the smallest 131.83 cm^2. The arithmetic mean in the sample was 143.79.

In seven cases the measured area of the skin showing coloration following the injection of the colorant was considerably larger (178.42 cm^2, 180.55 cm^2, 211.40 cm^2, 157.56 cm^2, 157.56 cm^2, 168.33 cm^2, 159.41 cm^2) than the areas of the skin over the lower part of the serratus anterior muscle in other specimens.

A possible explanation for this phenomenon may lay in the fact that all these seven cases belonged to a group of cadavers younger then 40 years, and all seven had prominent osteomuscular constitution.

It is a well-known fact that exercise or great physical strain result in muscle hypertrophy which leads to an increase in the muscle vascular system due to increased metabolic needs of the muscle[13-15].

This increase in the number of musculocutaneous perforators in the hypertophic musculature with the resulting increase of the area of the skin supplied by blood was also described by Taylor and Palmer in their study of the angiosomes in the human body[8,15].

During our research, low values of measured areas, between 85 cm^2 and 105 cm^2 in size, were recorded on several cadavers who were affected by diabetes and generalized arteriosclerosis. Having checked the case histories of each of the subjects, we excluded those who had suffered from these chronic diseases from our research. In this selection we were guided by the postulate that a compromised state of vascular system, which is the case in diabetes as well as arteriosclerosis, presents a drawback in the reconstructive surgery procedures involving free flaps [16-20].

The area of the skin that can be lifted together with the other components of the serratus anterior flap, taking into account even the smallest measured skin area in our sample, which is 131.83 cm^2, represents the size of the of the skin cover sufficient for reconstruction of defects on the face neck, hand and foot.

The statistical data analysis in our research shows that there is 99 percent probability of the mean value of the area of the skin to which blood is supplied by the musculocutaneous perforators of the lower part of the serratus anterior muscle being within the 143.79+-2.68 x 2.077 interval, that is, between 138.22 cm^2 and 149.36 cm^2.

The results of our research show the surface of the skin area to which blood is supplied by the musculocutaneous perforators of the lower part of the serratus anterior muscle, measured for the first time.

This anatomical research facilitates the forming of a musculocutaneous and/or osteomusculocutaneous serratus anterior flap with the skin cover adequately supplied by blood.

CONCLUSION

The results of this study show the size of the area of the skin that receives blood by way of the musculocutaneous perforators of the lower part of the serratus anterior muscle. Considering the most frequent clinical indications for the use of the serratus anterior flap – reconstruction of defects on the face, hand and foot – the measured areas fully correspond to the required skin cover size.

The research results show a balanced distribution of the musculocutaneous perforators, which facilitates safe clinical application.

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PROKRVLJENOST KOŽNOG PODRUČJA IZNAD DONJEG SEGMENTA MIŠIĆA SERRATUS ANTERIOR

SAŽETAK

Svrha ovog istraživanja je prikaz površine kožnog područja koje je prokrvljeno muskulokutanim perforatorima donjeg segmenta mišića serratus anteriora. Istraživanje prokrvljenosti kožnog područja izvršeno je na pedeset svježih leševa, primjenom injekcijske metode. Za prikaz površine prokrvljenog kožnog područja upotrebljena je crna tinta koja je injicirana u arteriju torakodorzalis, odnosno njene ogranke za donji segment mišića serratus anteriora. Mjerenje površine obojene kože, odnosno područja prokrvljenog muskulokutanim perforatorima izvršeno je prislanjanjem prozirnog milimetarskog papira na područje obojene kože i crtanjem granice tog područja. Računanje površine obojenog kožnog područja učinjeno je upotrebom planimetrijske metode uz pomoć osobnog računala, scannera i odgovarajućeg programa za izračun površina. Statistička obrada podataka o mjerenjima u našem istraživanju pokazuje da se u populaciji sa 99% vjerojatnošću može očekivati srednja vrijednost površine kože prokrvljene muskulokutanim perforatorima donjeg segmenta mišića serratus anterior u intervalu 143.79 +- 2.68 x (2.077), odnosno između 138.22 cm^2 – 149.36 cm^2. Rezultat našeg istraživanja omogućuje kliničku primjenu muskulokutanog i/ili osteomuskulokutanog režnja serratus anterior u plastično-rekonstruktivnoj kirurgiji, što do sada nije bilo moguće uslijed nepoznavanja površine kože koja se zajedno s mišićem može odignuti, odnosno zbog opasnosti od djelomične ili potpune nekroze prileţečeg kožnog segmenta.

FIGURE HEADINGS

Fig. 1. Injection of Indian ink into the thoracodorsal artery.

Fig. 2. Coloration of skin area following injection of Indian ink.

Fig. 3. Computer analyzed colored skin area.

Fig. 4. Skin surface area for each specimen with arithmetic mean.