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PENETRATION OF INTRAVASCULARY INJECTED PICKLE INGREDIENST INTO SHOULDER MUSCULES

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The data on the penetration of intravasculary injected pickle ingredients into muscles of the anterior extremity (shoulder) of swine are very scarce in the literature. The morphology and the topography of muscles, as well as blood vessels of the anterior extremity of swine, are mainly presented only from the aspect of the comparative anatomy of domestic animals. Anatomical-topographical properties of these muscles, and their vascularity, certainly have a high influence on the dynamics of the penetration of pickle ingredients into shoulder muscles of swine. Therefore, we have set the following tasks:

- to establish the anatomical-topographical and the morphological properties of the most important muscles (includes in the shoulder) of the anterior extremity, and to determine their weights;
- to study up the anatomical site of the arterial system, namely to analyse the vascularity of definite muscles of the shoulder;
- to follow the dynamics of the penetration of a definite pickle component into individual muscles of the shoulder, by using the radioactive markers.

MATERIALS AND METHODS

A n a t o m i c a l - t o p o g r a p h i c a l e x a m i n a t i o n s

The anterior extremities of swine, used for anatomical-topographical examinations, were separated from the thorax of sides of white meat hogs of domestic breed, weighing about 95 kg, by cutting the corresponding muscles of the synsarcous connexion: cranio-dorsally - m. brachiocephalicus; dorsally - m. trapezius and m. rhomboideus; caudo-dorsally - m. latissimus dorsi; caudo-ventrally - m. pectoralis ascendens, and from the medial side - m. serratus ventralis. The anterior extremity, separated from the carcass in this way, and after disarticulation of its carpal joint, is known as "shoulder" in the practice of meat industry.

Preparation of shoulder muscles was carried out by usual anatomical technique, using the corresponding instruments.

Radiographic examinations

As a contract means in the arteriography of the anterior extremity, namely shoulder, lead oxide and lead chromate mixed with gelatine were used.

Radiometric examinations

Prior to injection, the shoulders were cooled for 18 hous. The pickle was injected through a. axillaris in the quantity of 10 percents, calculated on the weight of bone-in shoulders. The pickle with marked phosphates, in the form of sodium ortophosphate, i.e. $Ha_2H\ (^{32}PO_4)_2$, whose activity was 5mCi, was used for the examination. The activity of samples taken from the surface of individual muscles was measured 1, 2, 3, 6, 12, 24 and 48 hours after injection, on the "Philips" universal counter.

RESULTS AND DISCUSSION

Anatomical-topographical and technological examinations

Besides other anatomical parts, the shoulder is composed of cut portions or intact muscles of the synsarcous connexion and of the muscles of the scapulo-humeral region.

Muscles of the synsarcous connexion (m. brachiocephalicus, m. latissimus dorsi and mm. pectorales) represent a rather significant muscle mass of the swine shoulder.

According to the data from the literature, m. brachiocephalicus in swine, as well as in equines and ruminants, consists of three parts: m. cleidooccipitalis, m. cleidomastoideu and m. cleidobrachialis. The stunted clavicle in swine is represented only by a rather difficultly observed, transversally striped band of connective tissue. Therefore, it is impossible to establish a distinct limit among these three muscles. Our examinations have shown that m. brachiocephalicus in swine is a unique muscle, beginning with two meaty parts: pars occipitalis and pars mastoideus. The colour of this muscle is not uniform. The nuances from pale-rosy to dark-red colour are observed.

M. latissimus dorsi, namely that part of this muscle which remains on the shoulder after cutting, has a triangular form due to the convergent direction of its muscle bundles. The muscle bundles are tender, streaked with fatty tissue and, therefore, of lighter pale-rosy colour.

Mm. pectorales in swine, as well as in other domestic mammals, are divided into two groups: mm. pectorales superficiales and mm. pectorales profundi. The first group of pectoral muscles includes m. pectoralis descendens and m. pectoralis transversus, whereas the second group includes m. pectoralis ascendens s. pars humeralis and m. pectoralis cleidoscapularis s. pars praescapularis.

The muscle bundles of m. pectoralis ascendens are at the beginning very rough and of lighter red-rosy colour. Immediately after insertion, they become thinner, more tender and somewhat darker in colour. On the contrary, the muscle bundles of m. pectoralis cleidoscapularis are to a considerable extent streaked with connective and fatty tissue, the pale-rosy colour of this muscle being therefore intensified.

M u s c l e s o f s c a p u l o-h u m e r a l r e g i o n include: m. deltoideus, m. infraspinatus, m. supraspinatus, m. teres minor, m. subscapularis, m. teres major, m. coracobrachialis, m. capsularis (lacking often), m. triceps s. quinticeps brachii, m. anconeus and m. tensor fasciae antebrachii.

In the available literature, m. triceps brachii has been described as the most significant muscle of the shoulder. According to the results of our examinations, the term "triceps" is not the appropriate name for this muscle because this muscle does not consist of three parts but of five clearly differentiated parts: pars dorsalis lateralis, pars ventralis lateralis and pars medialis making up a whole (in the literature, all the three parts together are named caput longum), then caput laterale and caput mediale. We have therefore named the muscle m. QUINTICEPS brachii.

Studying the macrostructure of m. quinticeps brachii, namely pars dorsalis lateralis, pars ventralis lateralis and pars medialis, we have established that their muscle bundles are thin and tender, and predominantly of light-rosy colour. Caput laterale shows a similar macrostructure. However, caput mediale is of dark-red colour and to a higher extent streaked with connective tissue.

Due to limited space, we are not in possibility to present the results for other muscles of the shoulder, which were studied up in details, too.

Table 1 presents the minimum, maximum and mean values of the weights of individual, most significant muscles of the shoulder.

Table 1.

Muscle	Weight in kg		
	Min.	Max.	Mean value
m. brachiocephalicus	0,110	0,125	0,116
m. latissimus dorsi	0,115	0,130	0,123
m. pectoralis ascendens	0,165	0,250	0,222
m. pectoralis cleidoscapularis	0,185	0,225	0,204
m. infraspinatus	0,300	0,385	0,353
m. supraspinatus	0,370	0,480	0,436
m. quinticeps brachii:			
- pars dorsalis lateralis			
- pars ventralis lateralis	0,470	0,525	0,504
- pars medialis			
- caput laterale	0,120	0,130	0,129
- caput mediale	0,050	0,065	0,057

From the presented data, it can be seen that among the examined muscles of the shoulder, m. quinticeps brachii shows the highest value of the weight.

The amounts of proteins, fat and water found in m. quinticeps brachii are given in Table 2. The results of chemical examination of m. quadriceps femoris, a muscle of the posterior extremity being very similar to m. quinticeps brachii regarding its macrostructure, are also presented in the table for the purpose of comparison.

Table 2.

Muscle	Percentage		
	Water	Fat	Proteins
Pars dorsalis lateralis			
Pars ventralis lateralis	76,30	2,25	20,60
Pars medialis			
Caput laterale	76,60	1,98	21,20
Caput mediale	75,20	4,13	19,30
Quadriceps femoris	76,60	2,11	20,41

The presented results show that regarding the basic chemical indices, there are not any more essential differences between m. quadriceps femoris of the posterior extremity and the main muscle mass - m. quinticeps brachii of the anterior extremity.

R a d i o g r a p h i c e x a m i n a t i o n s

The sites of blood vessels of the shoulder, photographed radiographically and obtained by anatomical preparation, are schematically presented in Figure 1.

Fig. 1. Sheme of the arterial system of the right anterior extremity of swine

1. a.axillaris; 2. a.subscapularis; 3. a.brachialis; 4. a. thoracicodorsalis; 5.a. circumflexa humeri posterior; 6. a. circumflexa scapulae; 7. a. circumflexa humeri anterior; 8. a.profunda brachii; 9. a.collateralis ulnaris (proximalis); 10. a.collateralis radialis (distalis); 11. a.mediana; 12. a.interossea communis; 13. a. radialis; 14. a.ulnaris; A. arterial branch not fount in the available literature.

In a certain number of works, there can be found the datum that on occasion of pickle injection into muscles of the shoulder, the pickle is injected through a. subscapularis or truncus brachiocephalicus. The results of our examinations show that truncus brachiocephalicus is lacking in swine, what was also confirmed by the data of Ellenberger-Baum. A.subscapularis is, in fact, a branch of a.axillaris (as presented in the scheme), which vascularized for the most part the muscles of the scapula. Analysing the vascularity

of the shoulder, it can be seen that the majority of the muscles of the synsarcous connextion is not directly covered with arterial vessels which branch from a.axillaris. Comparing our arteriographic finding with the data published in the literature up to now, it comes out that certain differences can be observed in the arterial system of the shoulder of swine. First of all, these differences refer to the vascularity of musculature of distal parts of the shoulder. Namely, on the proximal third of the medial side of ossa antebrachii, somewhat over a. interossea communis, and starting from a.mediane, there separates a considerably developed branch, which extends caudally and then ventrally and which directs its branches toward the metacarpus. Such sites of blood vassels in the distal part of the anterior extremity of other domestic animals have not been described in the literature.

Direct vascularity through developed arteries was expressed to the most extent in m. infraspinatus and then in m. supraspinatus. According to our examinations, however, m. quinticeps brachii shows the most intensively developed capillary network. That means that the total lumen of blood vessels is to the highest extent expressed in this muscle. Considering the arterial system of the shoulder musculature, it can be emphasized that it is more intensively developed in the scapula region.

R a d i o m e t r i c e x a m i n a t i o n s

Our previous examinations regarding the penetration of intravasculary injected pickle ingredients into muscles of the posterior extremity of swine have shown that this process can be divided into two stages: mechanical forcing of the pickle and osmotic-diffusion processes. By radiographic and radiometric examinations, we have established that intraarterially injected pickle at first fills the volume of blood vessels and then the capillary system. After that, there take place physico-chemical processes of osmosis and diffusion, namely, binding of pickle ingredients. Penetration of pickle ingredients from blood vessels into the capillary system is carried out under the effect of a mechanical power, i.e. the pressure under which the pickle is injected. Penetration of the pickle from the capillary system into intercellular spaces is most probably the result of the breaking of the capillary system. The limited space does not

allow us to present all the results obtained by the examination of the penetration of pickle ingredients into muscles of the shoulder. Therefore we shall limit ourselves only to the data obtained by radiometric measurements of the intensity of radioactive impulses in individual muscles of the shoulder. When making the choice of muscles, we tried to include in the examination both the muscles being indirectly supplied with blood, namely receiving the pickle through collaterals and osmotic-diffusion processes. Measurements of the activity were done on the surface of muscles. The purpose wos to establish what time the pickle ingredients need to get, directly from the arterial network, to superficial parts of the muscles.The results of the ^{32}P activity measurements are presented in Table 3.

Table 3.

Muscle	h	aktiv.100"	imp./min.	imp./min./g
1	2	3	4	5
m. pectoralis ascendens (pars humeralis)	1	0	0	0
	2	0	0	0
	3	20	12	21
	6	30	18	40
	12	2067	1240	3640
	24	84	50	150
	48	80	18	89
m. cleidoscapularis (pars praescapularis)	1	0	0	0
	2	0	0	0
	3	48	29	66
	6	42	24	65
	12	1195	717	2708
	24	25	15	45
	48	8	5	9
m.supraspinatus	1	1014	680	2060
	2	4460	2676	7760
	3	6070	3642	12070
	6	775	435	684
	12	2540	1524	5080
	24	855	513	1200
	48	1477	886	1870

1	2	3	4	5
m.infraspinatus	1	2541	1524	5260
	2	6036	4101	10580
	3	10684	6388	12280
	6	3762	2257	5130
	12	6519	3911	15012
	24	3302	1981	4670
	48	2703	1621	3730
m.quinticeps brachii (caput laterale)	1	0	0	0
	2	0	0	0
	3	18	10	31
	6	65	39	78
	12	431	258	860
	24	150	90	308
	48	135	81	208
m.quinticeps brachii pars dors.later. pars vent.later. pars medialis (caput longum)	1	0	0	0
	2	0	0	0
	3	3	2	4
	6	93	56	148
	12	765	459	1080
	24	216	129	570
	48	553	331	550

Immediately after the injection of the pickle (an hour) into m.infraspinatus and m.supraspinatus, a large number of impulses was registered. In the interval between the second and the third hour, the "plateau" was achieved in these muscles; the intensity of this plateau was maintained up to the 12th hour. That means that the pickle ingredients were distributed in these muscles in a very quick and homogenous way. Contact between the pickle ingredients and the examined muscle tissue was realised within the first 12 hours.

In m. quinticeps brachii, these processes took place in the similar way, with the exception that the stability plateau of the registered impulses was formed after 6 hours, with a tendency of increase up to the 12th hour.

In the muscles of the synsarcous connexion, being not directly vascularized from a.axillaris, the impulses were not registered during the first two hours. That means that within this period, the pickle ingredients did not reach the superficial layers of the

examined muscles. The stability plateau of radioactive impulses was obtained at the 12th, namely 24th hour.

Bringing together the realtion between the vascular system and the muscle mass on the one side, and the intensity of radioactive impulses registered in different time intervals after the injection of the pickle on the other side, it can be observed that the penetration of ingredients is just proportional to the extent of muscle vascularity.

M.infraspinatus and m.supraspinatus, as presented in the results obtained by radiographic examinations, show mostly developed direct vascularity and, consequently, most intensively expressed effect of mechanical introduction of the pickle. During the initial stage of curing, the developed capillary system in m.quinticeps brachii probably retains the pickle for a certain shorter period of time. However, due to the increased turgor, the capillary network breaks and a more intensive development of osmotic-diffusion processes takes place, accelerating thus the process of the penetration of pickle ingredients. In our case, this was registered by the corresponding intensity of impulses on the surface of this muscle.

On the base of the results of our examinations, and according to the rate of the penetration of pickle ingredients, the muscles of the shoulder can be divided into three groups: 1) m. infraspinatus and m. supraspinatus, having the highest penetration rate, 2) m. quinticeps brachii, having retarded penetration rate, and 3) m. pectoralis ascendens and m. cleidoscapularis, having the lowest penetration rate. More detailed examinations point out that among individual parts of the same muscle, there exist definite differences in the intensity of radioactive impulses, namely in the rate of the penetration of pickle ingredients. From the standpoint of the practice, these differences are not so significant as it is the case when individual groups of muscles are concerned. On the base of our examinations, it comes out that the contact between the pickle ingredients and the muscle tissue of the shoulder is realised within the first 24 hours.

CONCLUSION

The results of our examinations enable us to point out the following:

1. The main muscle mass of the shoulder of swine includes m.triceps brachii which, in this kind of animals, consists of five clearly differentiated parts and therefore we named it m. quinticeps brachii. According to its technological properties (colour, consistency, macrostructure, massiveness and others), this muscle is very similar to m. quadriceps femoris of the posterior extremity.

2. Vascularity of shoulder musculature of swine differs to some extent from the vascularity of other animals for slaughter, mainly in the distal part of the extremity. Namely, from a. mediane, on the proximal third of the medial side of ossa antebrachii, there separates a considerably developed arterial branch which supplies with blood the belonging musculature of this part of the anterior extremity and which has not been described in the literature up to now.

3. There has been established the correlation between the volume of the vascular network and the dynamics of the penetration of pickle ingredients being intraarterially injected into shoulder muscles. However, the muscles vascularized to a lower extent or being not supplied with blood directly from a. axillaris and its branches (muscles of synsarcous connexion), receive also sufficient quantities of pickle ingredients through well developed collaterals and through osmotic-diffusion processes.

4. Intravasculary injected pickle penetrates into shoulder muscles by mechanical forcing - injection and through biochemical, namely biophysical processes.

5. According to the rate of the penetration of intravascularly injected pickle ingredients, the muscles of the shoulder can be divided into three groups: 1) m. infraspinatus and m. supraspinatus, having the highest penetration rate, 2) m. quinticeps brachii, having retarded penetration rate, and 3) m. pectoralis ascendens and m. cleidoscapularis, having the lowest penetration rate.