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Anatomical Study and Clinical Application of the Axillary Artery Branching Patterns 양 기 욱 2019년 8월

박 사 학 위 논 문

Anatomical Study and Clinical Application of the Axillary Artery Branching Patterns

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Anatomical Study and Clinical Application of the Axillary Artery Branching Patterns

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이 논문을 박사학위 논문으로 제출함

2019년 8월

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1. Introduction

In humans, the axillary artery (AA) is a large blood vessel delivering oxygen-filled blood to the chest, axilla, and upper extremities. It originates from the side edge of the first rib before it is called the subclavian artery (1).

The axillary artery often consists of three parts depending on the artery location relative to the pectoralis minor muscle, which is superficial to the artery. The first part is proximal, the second part is posterior, and the third part is distal to this muscle. In normal anatomy, six branches arise from the axillary artery. The first branch, the superior thoracic artery (STA), originates from the first part. The second and third branches, the thoracoacromial artery (TAA) and lateral thoracic artery (LTA), originate from the second part. The fourth, fifth, and sixth branches, the subscapular artery (SSA), anterior circumflex humeral artery (ACHA), and posterior circumflex humeral artery (PCHA), respectively, originate from the third part (2).

The axillary artery direction depends on the upper limb position (3). In anatomical position, the artery is accompanied by the axillary vein and is closely related to the brachial plexus and its branches (4). The axillary artery occupies a part of the scapular anastomosis to the subclavian artery, which is clinically important for diagnostic interpretation (5-7). The origin and morphology of the axillary artery branches are diverse, and numerous studies report various variations. In most of these studies, the axillary artery branches were often found to be branched together (8-11).

Details regarding deviation from the normal arterial pattern and variations of the axillary artery are crucial for anatomists, plastic and

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orthopedic surgeons, vascular radiologists, and interventional cardiologists (12-16). In addition, injuries of the brachial plexus are quite common and require exploration and repair. The axillary artery variations is a concern during these procedures (17-19).

Although the branching pattern and variations of the axillary artery are crucial, only a few studies compare its branching patterns and origin. In this study, the branching patterns and origin of the axillary artery and its correlation was analyzed. This information has practical implications and can be helpful for accurate diagnostic interpretation. This study aimed to determine the branching patterns and variations of the axillary artery.

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2. Materials and Methods

2.1. Prevalence and length of the axillary artery:

In this study, 59 upper limbs (from 30 donated cadavers, 30 right and 29 left) were dissected. Each cadaver was placed in a supine position with arms abducted and palms facing up. The skin, superficial fascia, and adipose tissue were removed to expose the axillary artery. The pectoralis major and pectoralis minor muscles were dissected. After the brachial plexus, axillary vein, teres major muscle, pectoralis major muscle and pectoralis minor muscle were dissected from each muscle and fascia, the axillary artery was identified. After identification, the length between the lateral border of the first rib and the inferior border of the teres major muscle was measured by digital calipers (NA500-300S, Blue bird, Korea) and defined as the reference line (1, 2). The branching patterns and variations of the axillary artery were analyzed. The length from the lateral border of the first rib to the branching points of the axillary artery was compared with the length of the reference line (in percentile).

2.2. Topography of the axillary artery:

The branching points of the axillary artery were analyzed and divided into three parts. Each branching point was defined as the length from the lateral border of the first rib to the branching point. All branching points were calculated with respect to the reference line in percentile. Their branching patterns were classified according to the branching

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combination. The difference in the branching point of each artery was compared according to the branching pattern, sex and left and right upper limbs. And the correlation between the branching points and three parts of the axillary artery was analyzed to sex and left and right upper limbs.

2.3. Statistical analysis:

All statistical analyses were conducted using SPSS (version 20.0, IBM SPSS®; Chicago, IL). Pearson correlation test and Kruskal - Wallis test were used to analyze the relationship between the variations of the axillary artery. P values <0.05 were considered to indicate statistical significance.

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3. Results

3.1. The origin and length of the axillary artery:

The average length of the axillary artery was found to be 112.50 mm (reference line; range: 80 - 150 mm). With respect to reference line, the length of the starting point of the second part of the axillary artery was 33.39% (mean length: 37.56 ± 1.28 mm). The length of the starting point of the third part of the axillary artery was 69.51% (78.20 ± 1.78 mm). STA originated from 22.90% (25.76 ± 1.11 mm). TAA and LTA originated from 37.93% (42.67 ± 1.43 mm) and 48.25% (54.28 ± 1.69 mm), respectively. SSA, ACHA, and PCHA originated from 57.53% (64.72 ± 1.49 mm), 74.57% (83.89 ± 1.84 mm), and 75.14% (84.54 ± 1.54 mm), respectively (Figure 1).

3.2. Correlation among branches of the axillary artery:

The length of the starting point of the second part of the axillary artery positively correlated with the origin of STA ($r = 0.26$, $P < 0.05$, Figure 2) and TAA ($r = 0.56$, $P < 0.05$, Figure 3). The length of the starting point of the third part of the axillary artery negatively correlated with ACHA ($r = -0.32$, $P < 0.05$, Figure 4). LTA distribution positively correlated with SSA ($r = 0.47$, $P < 0.05$, Figure 5) and AHCA ($r = 0.31$, $P < 0.05$. Figure 6). There was a positive correlation between AHCA and PHCA ($r = 0.71$, $P < 0.05$, Figure 7). Other branches did not have any correlation among themselves.

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3.3. Branching pattern of the axillary artery:

I examined the branching patterns of the axillary artery to examine the relationship between the origin of the branching point and the distribution pattern. Considering every branch given off directly by the axillary artery, the branches were 3 - 6 in number and of 9 types. The axillary artery without any variation was found in 15 cases (Figure 8). The most frequently detected branching pattern was LTA and SSA branching together in 22 cases (Figure 9), followed by a common branch for AHCA and PHCA in 19 cases (Figure 10). One trunk for LTA and SSA and one trunk for ACHA and PCHA were found together in 12 cases. TAA and LTA were branched together in 9 cases (Figure 11). SSA, PHCA, and AHCA originated from a common trunk in 2 cases. TAA, LTA, and PHCA were branched together in one case. LTA, SSA, and PHCA were branched together in one case. TAA, LTA, and SSA were branched together in one case. SSA and PHCA were branched together in one case. There was no statistically significant difference with respect to sex and left and right upper limbs.

3.4. Topographical changes in branches according to the branching pattern of the axillary artery:

The branching pattern was classified into 5 types: typical, common branch of TAA and LTA, common branch of LTA and SSA, common branch of ACHA and PCHA, and two common trunks for LTA/SSA and ACHA/PCHA. The origin of 6 branches was analyzed according to these branching patterns (Table 1). Compared to typical pattern, STA originated distally in atypical types; however, the difference was not significant (P = 0.330). When LTA originated with TAA, its origin was more proximal (P = 0.004). When PCHA originated with ACHA, its origin was more distal (P = 0.021).

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Table 1. The length of the branches of the axillary artery and its correlation

	Typical	TAA+LTA	LTA+SSA	ACHA+PCHA	LTA+SSA ACHA+PCHA
STA	22.6 ± 6.7	27.9 ± 11.0	23.6 ± 10.5	29.6 ± 7.7	27.4 ± 7.7
TAA	44.6 ± 7.7	45.6 ± 9.3	43.0 ± 14.0	39.3 ± 12.9	41.7 ± 10.9
LTA**	55.7 ± 13.1	48.7 ± 9.5	54.7 ± 17.8	50.5 ± 6.4	58.6 ± 10.4
SSA	65.9 ± 10.9	69.7 ± 10.3	59.3 ± 15.8	65.7 ± 9.7	61.4 ± 9.6
ACHA	79.6 ± 14.4	84.39 ± 7.8	81.2 ± 15.3	98.2 ± 13.8	85.3 ± 8.5
PCHA*	80.0 ± 12.8	84.3 ± 7.1	88.5 ± 6.9	97.8 ± 13.9	85.4 ± 8.4

*$P < 0.05$
**$P < 0.01$

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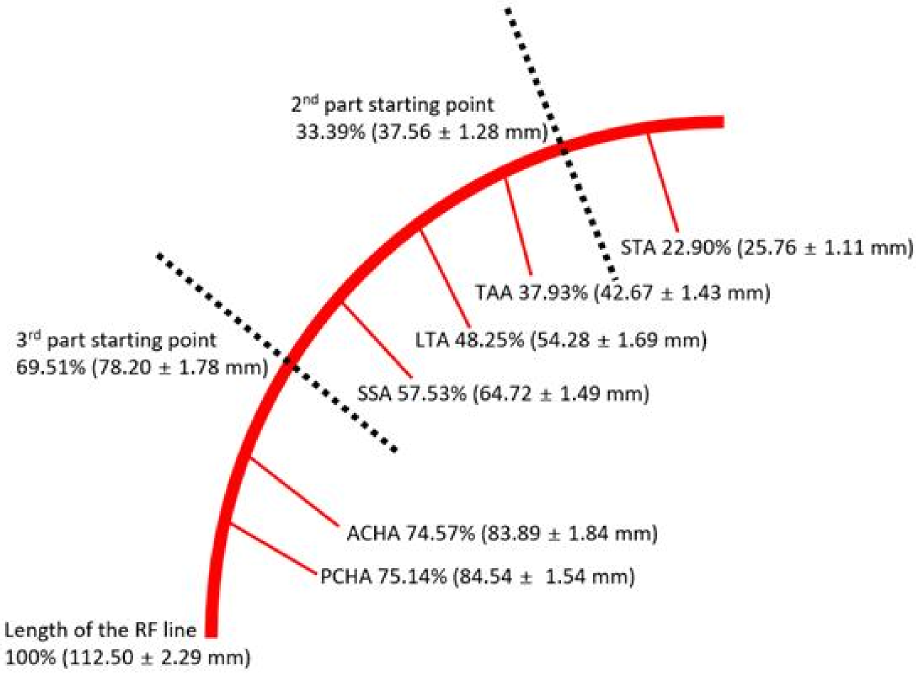

Figure 1. The average length and percentage by the reference line of the branching points of the axillary artery.

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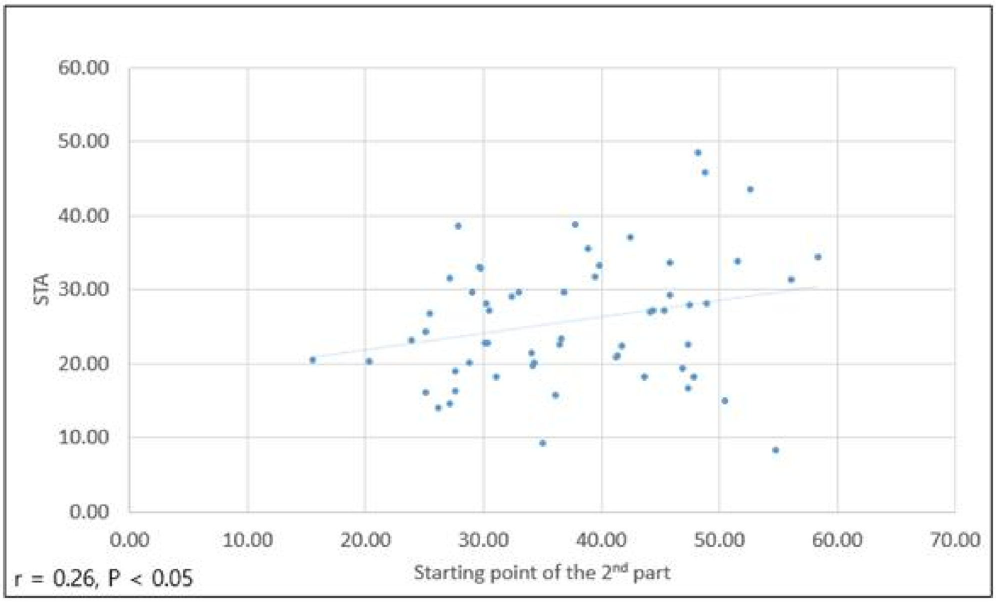

Figure 2. The correlation between the starting point of the second part of the axillary artery and the origin of STA.

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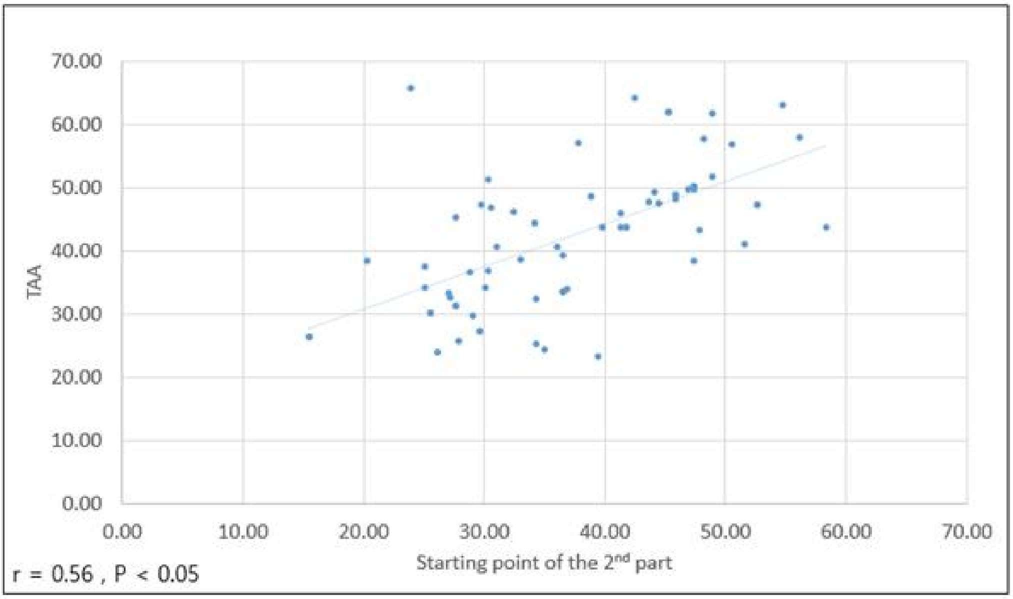

Figure 3. The correlation between the starting point of the second part of the axillary artery and the origin of TAA.

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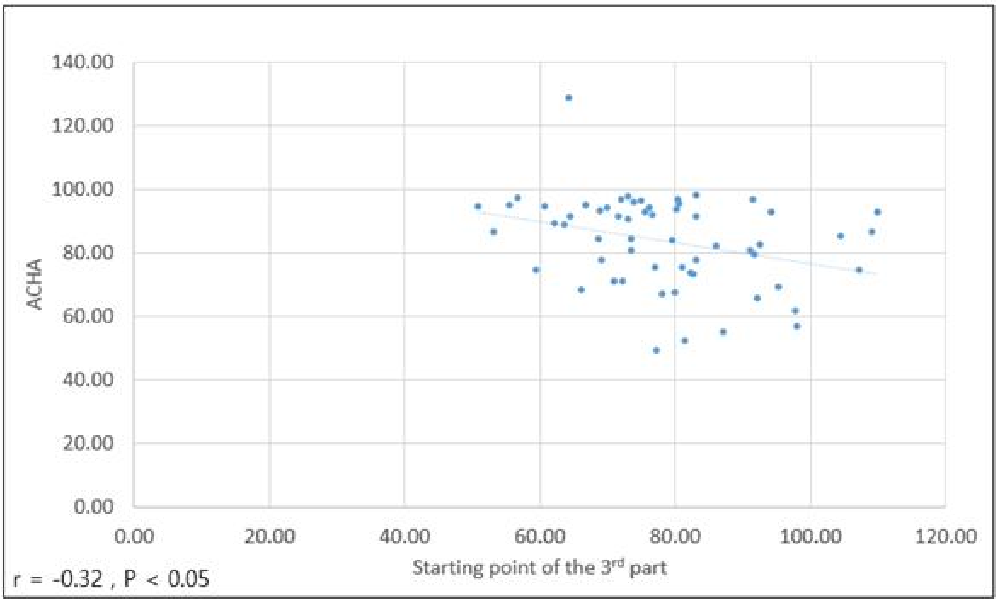

Figure 4. The correlation between the starting point of the third part of the axillary artery and the origin of ACHA.

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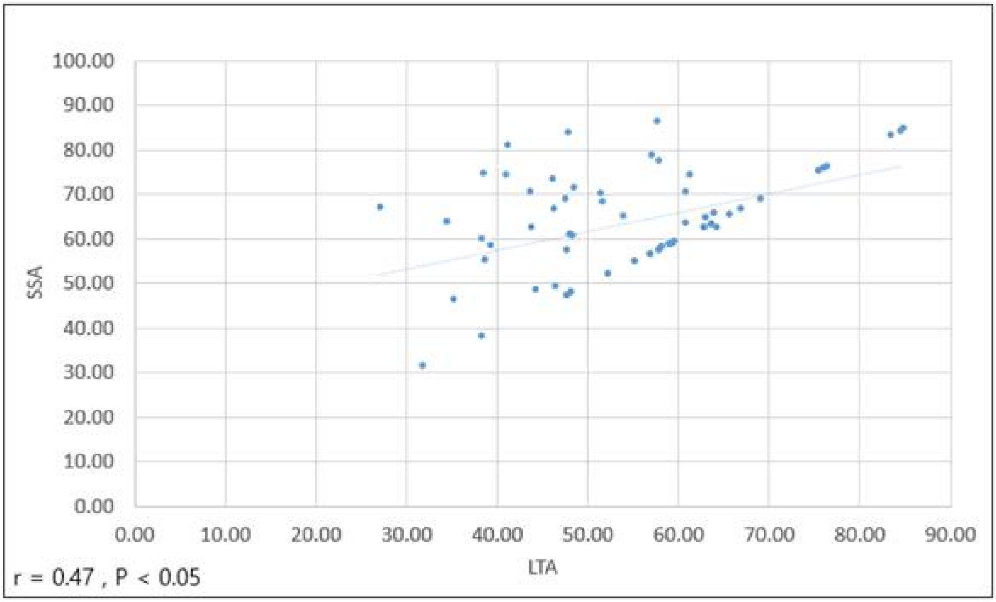

Figure 5. The correlation between the origin of LTA and the origin of SSA.

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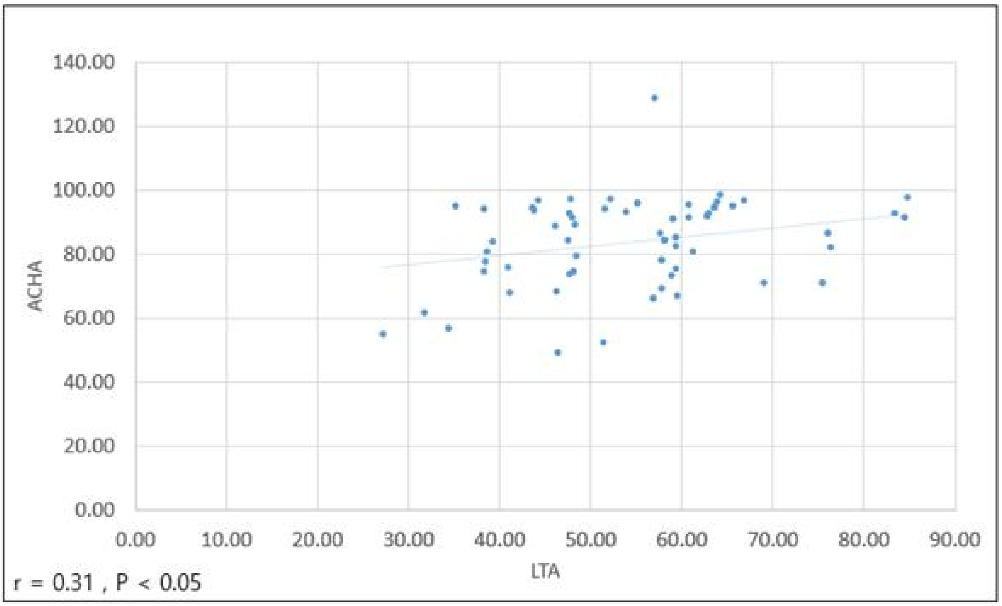

Figure 6. The correlation between the origin of LTA and the origin of ACHA.

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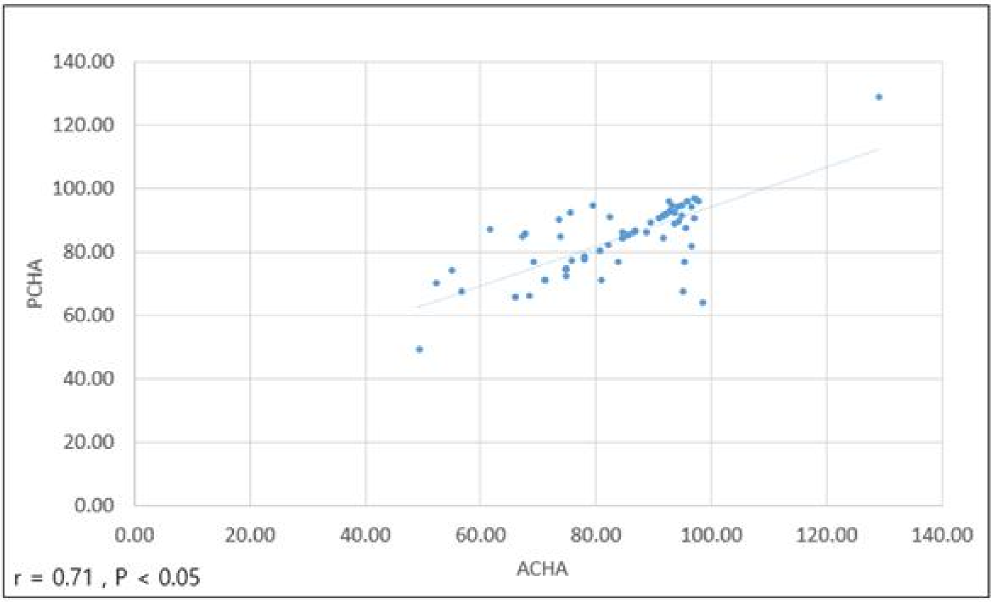

Figure 7. The correlation between the origin of ACHA and the origin of PCHA.

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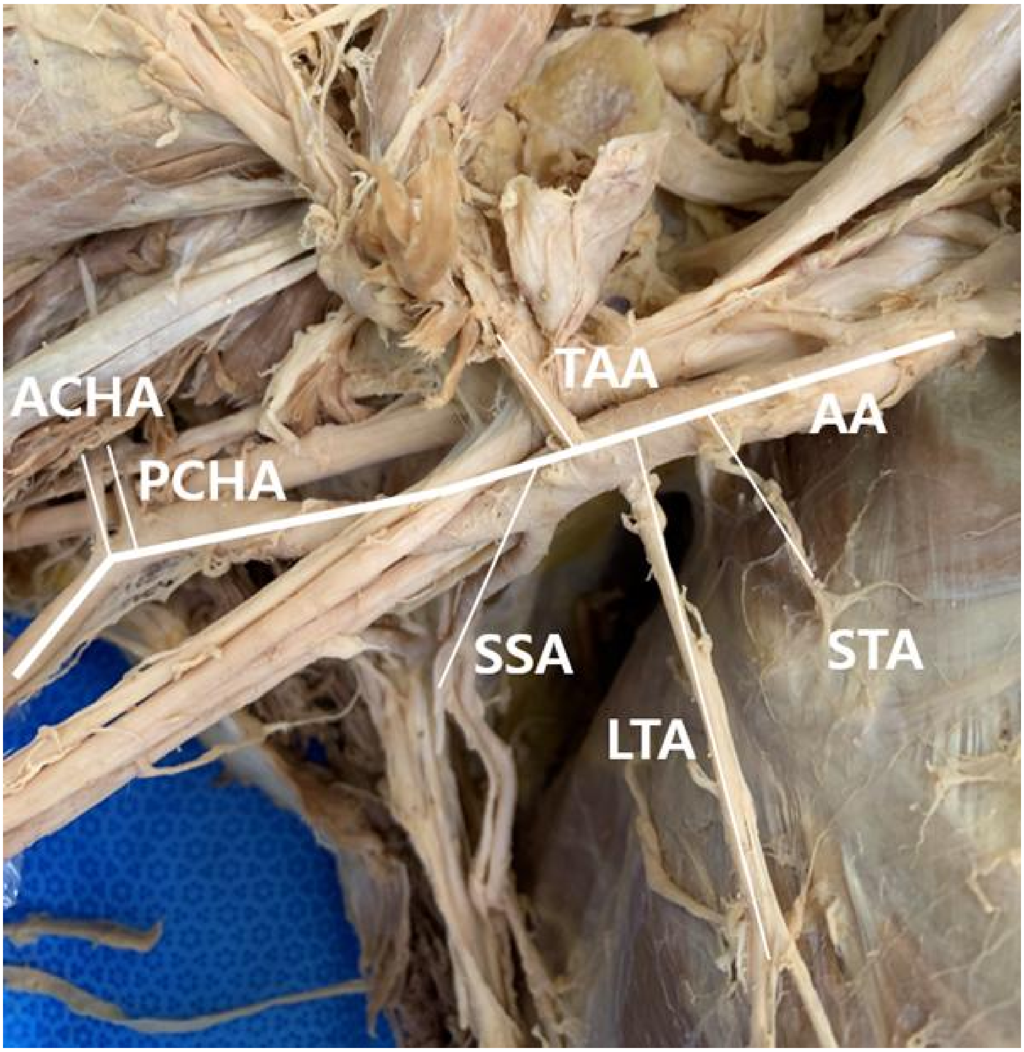

Figure 8. The axillary artery without variation at the right side.

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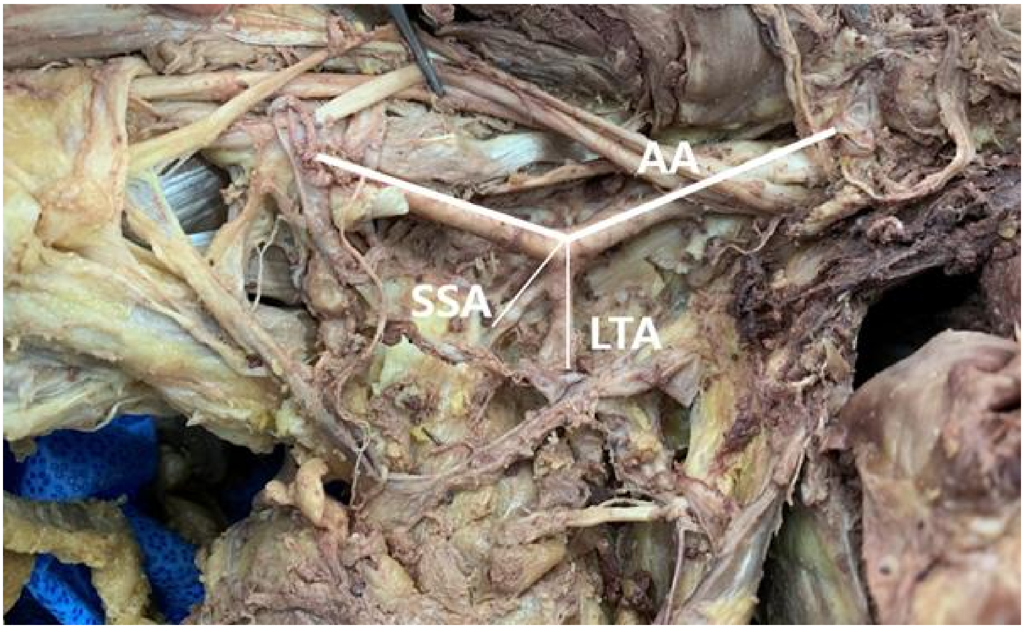

Figure 9. The LTA branched with the SSA at the right side.

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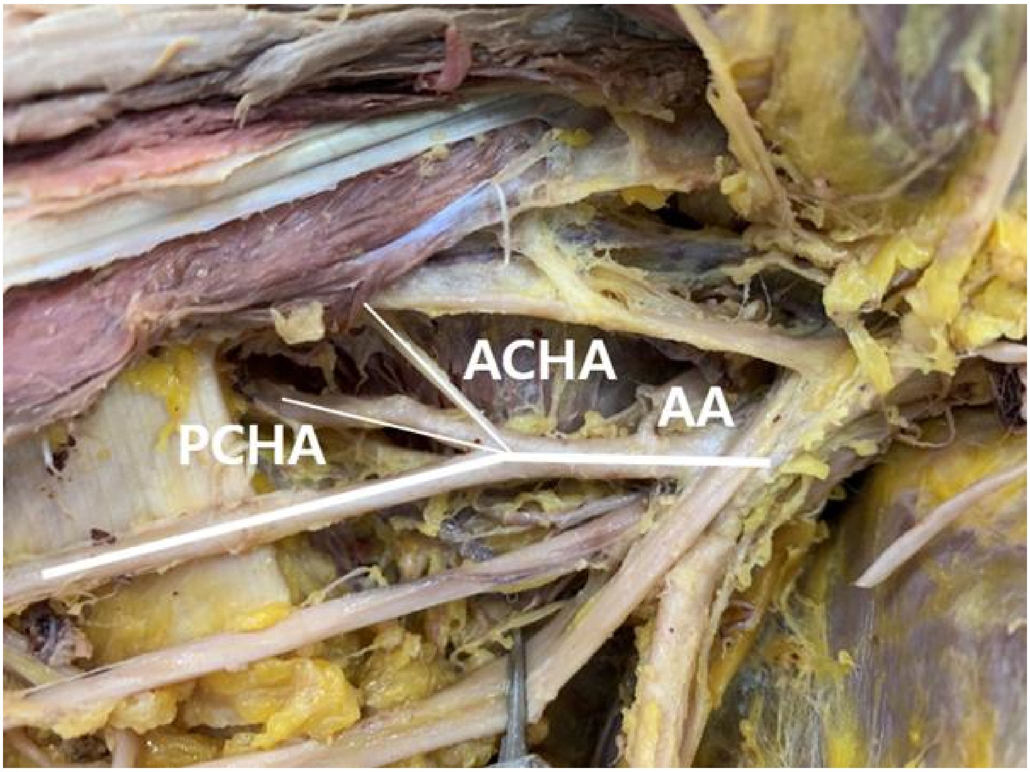

Figure 10. The ACHA branched with the PCHA at the right side.

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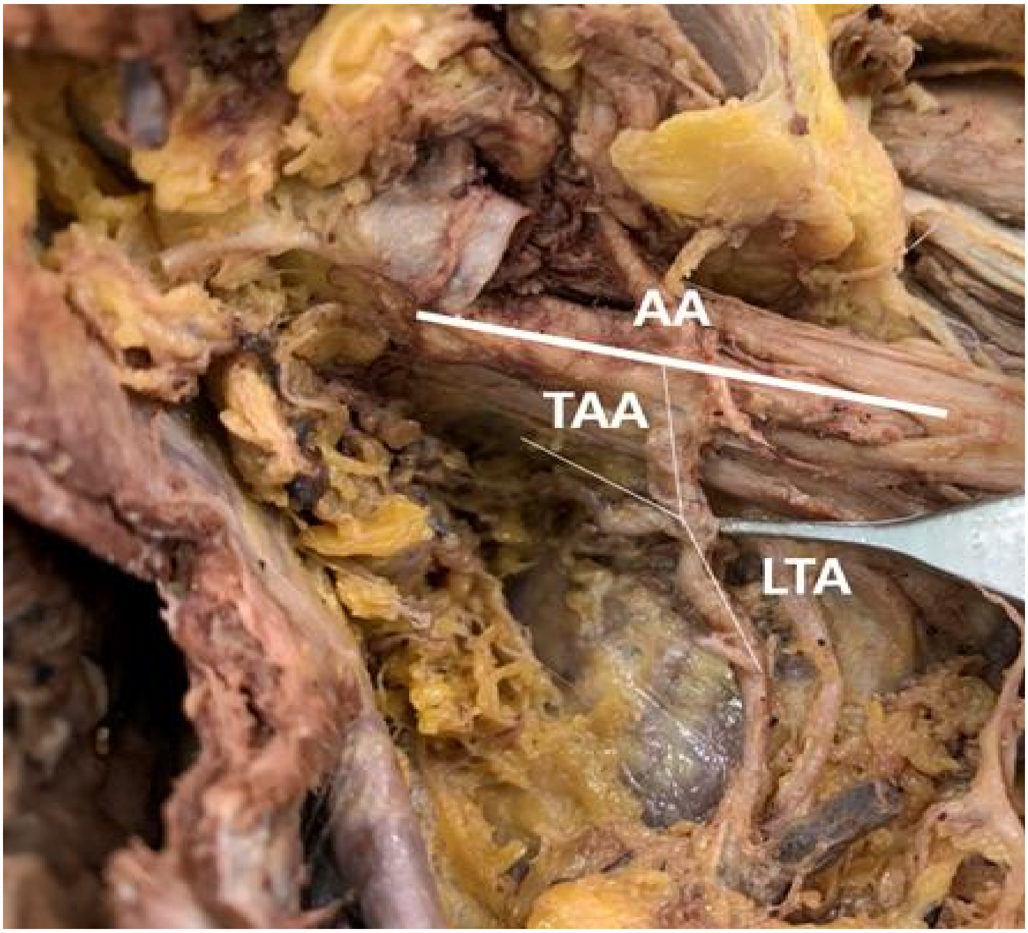

Figure 11. The LTA branched with The TAA at the left side.

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4. Discussion

In this study, the length of the axillary artery as reference line was found to be 80 - 90 mm in 4, 90 - 100 mm in 15, 100 - 110 mm in 9, 110 - 120 mm in 15, >120 mm in 16 cases. With respect to this reference line, the axillary artery was divided into three parts. The first, second, and third parts were 33.39%, 36.12%, and 30.49%, respectively. The average length of the origin of the six branches was also investigated. Interestingly, SSA originated from 57.53% in the second part of the axillary artery.

The anatomical variation of the axillary artery is clinically important because various blood vessels and nerves pass through it (20-22). In particular, branches of the axillary artery are quite diverse from the bases, with two or three arteries branching together. These branches correlate with each other based on their origin. As expected, there was a positive correlation between AHCA and PHCA. The origin of LTA was positively correlated with that of SSA. Interestingly, the origin of PCHA was negatively associated with the length of the third part. The origin of the branches of the axillary artery varied according to the branching patterns. These data indicated hypothesis that these arteries develop simultaneously, and their branching patterns may not be random.

Nine types of branching patterns of the axillary artery were found. This result was comparable with those of previous studies (10, 23, 24). The patterns and origins of the axillary artery branches have been investigated, but studies about the correlation among these patterns and origins were lacking in other studies (8, 9, 10, 23). Remarkably, the origins of LTA and PCHA were significantly different according to their

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branching patterns, suggesting that the morphology of the axillary artery during development influences the branching point and it has a pattern that LTA originated with TAA, its origin was more proximal and PCHA originated with ACHA, its origin was more distal. Until now, the arterial division was known as random. However, our results proposed hypothesis that the branching pattern and branching point are strongly associated and have unidentified regulation that one artery can correlate the position of another artery. Embryologic approach will be helpful performed in future to confirm this hypothesis.

Studies about the patterns and origins of the axillary artery branches and their correlation are important for clinicians (5-7). Patients with severe trauma to the shoulder and upper chest should be clinically assessed for vascular damage and musculoskeletal evaluation (17-19). In addition, it will be helpful to recognize and understand such a variation, even in radiographic procedures, to increase the accuracy of the technique and to reduce unnecessary complications (25, 26). Based on an accurate understanding of the axillary artery branching, as in this study, understanding the branching patterns and local anatomical variations may be helpful in the accurate assessment and proper management of the injured area.

This study investigated the patterns and variations of the axillary artery to provide useful information to clinicians especially dealing with the axillary region in the case of reconstructive surgery. However, further studies are necessary to accumulate more accurate information such as the relevance of the brachial plexus through more dissection. It is necessary to fill these deficiencies through steady study on the axillary artery.

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5. Summary

In this article, the morphology and variation of axillary artery were investigated. The axillary artery was divided into three parts. The superior thoracic artery (STA) was in the first part. The thoracoacromial artery (TAA) and, the lateral thoracic artery (LTA) were in the second part. And the subscapular artery (SSA), the anterior humeral circumflex artery (AHCA), the posterior humeral circumflex artery (PHCA) were in the third part. I investigated each correlation and kind of variations. The average length of the axillary artery was calculated and this length was defined as reference line. Based on this reference line, the length of the three parts were calculated by percentile. And the length of the branches of the axillary artery were calculated by percentile. The origin of LTA were correlated with that of SSA and AHCA, respectively. And there was a positive correlation between AHCA and PHCA. The number of branches ranged from 3 – 6 and 9 types. The most frequent branching pattern was common origin of the LTA and SSA. This information is particularly useful for surgeons and clinicians. I tried to provide important information to anatomical research and clinicians.

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Anatomical Study and Clinical Application of the Axillary Artery Branching Patterns

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(Supervised by Professor Choi, In Jang)

(Abstract)

This study aimed to determine the branching patterns and variations of the axillary artery. The length of the branching points of the axillary artery from the rib was compared with respect to the average length of the axillary artery. Based on the average length of the axillary artery, the length of the first, second, and third parts was analyzed. The origin of the lateral thoracic artery (LTA) was correlated with that of the subscapular artery (SSA) and the anterior humeral circumflex artery (AHCA). There was a positive correlation between AHCA and the posterior humeral circumflex artery (PCHA). The branches were 3 - 6 in number and 9 branching patterns. The most frequent branching pattern was a common origin of LTA and SSA (22/59). ACHA and PCHA originated together in 19 cases, and both patterns were combined in 12

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cases. The thoracoacromial artery (TAA) and LTA branched together in 9 cases, and a common trunk for SSA, ACHA, and PCHA was found in 2 cases. The branching patterns and variations of the axillary artery are useful for surgeons and clinicians for accurate diagnostic interpretation and graft surgery.

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겨드랑동맥 분지양상에 대한 해부학 연구와 임상 적용

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의학과 해부학 전공
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(초록)

겨드랑동맥은 세 구획과 여섯 개의 분지로 구성되어있다. 겨드랑동맥 분지의 형태와 변형은 임상의에게 매우 중요하다. 하지만 아직 이에 관한 연구가 부족하여 본 연구에서 겨드랑동맥의 분지 형태와 변이를 연구하였다. 30구의 기증된 시신에서 59쪽의 상지에서 겨드랑동맥의 형태를 연구하였다. 위가슴동맥 (STA)은 겨드랑동맥의 첫 번째 구획에 위치하였다. 가슴어깨동맥 (TAA)과 바깥가슴동맥 (LTA)은 두 번째 구획에 위치하였고, 어깨밑동맥(SSA), 앞위팔휘돌이동맥 (AHCA), 뒤위팔휘돌이동맥 (PHCA)은 세 번째 구획에 위치하였다. 각 분지의 길이가 겨드랑동맥 시작점을 기준으로 하여 측정되었고, 분지와 구획 간의 통계적 연관성이 평가되었다. 겨드랑동맥의 평균 길이는 112.50 mm이었고, 이 길이를 기준선으로 정의하였다. 이 기준선을 기준으로 제 1, 제 2 및 제 3 구획은 각각 37.56%, 39% 및 30.05%에 위치하였다. STA는 25.11%에 위치하였다. TAA와 LTA는 각각 42.67 %와 54.82 %에 위치하였다. SSA, ACHA, PCHA는 각각 64.72%,

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83.89% 및 84.53%에 위치하였다. LTA의 위치와 SSA 및 AHCA의 위치는 각각 양의 상관관계가 있었다. 그리고 AHCA와 PHCA 사이에는 양의 상관관계가 있었다. 겨드랑동맥의 형태는 가지의 수가 3개부터 9개까지 관찰되었다. 가장 빈번한 형태는 LTA와 SSA가 한 곳에서 분지가 된 형태였고 (22/59), AHCA와 PHCA가 같이 분지된 형태는 59쪽 중 19쪽에서 관찰되었다. 앞의 두 가지 형태가 12쪽에서는 동시에 관찰되었다. TAA와 LTA가 함께 분지한 것은 9쪽에서 발견할 수 있었고, SSA, AHCA와 PHCA가 2쪽에서 함께 분지 되었다. 겨드랑동맥의 분지형태나 변이에 관한 이번 연구 결과가 임상의에게 수술이나 시술 시 유용한 정보가 되고자 하였다.

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