Original Article

Indian Journal of Anatomy
Volume 2 Number 1, January - June 2013

A Study on the Vascular Foramen at the Ends of the Ulna and the Nutrient Foramen on the Ulna

Harish A. Wankhede*, P.B. Hosmani, M.M. Baig***, Dipti A. Nimje******

Abstract

Long bones are supplied by one or two main diaphyseal nutrient arteries. Along with these nutrient arteries numerous epiphyseal and metaphyseal arteries passes through the vascular foramina which penetrate bones near their ends, often at fairly specific sites. This epiphyseal and metaphyseal arterial supply is richer than the diaphyseal supply. In the present study 220 dried human adult ulnas were studied. The vascular foramina at the upper and lower ends of the ulna were observed and numbered. Topographical distributions of the nutrient foramina's were also studied. Results were analyzed statistically. It shows that the difference between the number of vascular foramina at the upper and lower end of ulna is highly significant. So study concluded that the upper end of the ulna has rich blood supply than the lower end. Therefore the lower end is more liable for ischemic necrosis, non-union and delayed union when get fractured. Knowledge of such vascular foramina at the end of long bone is important to clinicians, surgeons and anatomist in the present era of modern surgeries like microvascular bone grafting.

Keywords: Nutrient arteries; Vascular foramina; Ulna; Bone grafting.

Introduction

Long bones are supplied by one or two main diaphyseal nutrient arteries which enter the shaft obliquely through nutrient foramina leading into nutrient canals. Their sites of entry and angulations are almost constant and characteristically directed away from the dominant growing epiphysis. Nutrient arteries do not branch in their canals, but divide into ascending and descending branches in the medullary cavity. These approach the epiphyses, dividing repeatedly into smaller helical branches close to the endosteal surface. These endosteal vessels are vulnerable during operations which involve passing metal implants into the medullary cavity, e.g. intra-medullary nailing for fractures.[1]

Near the epiphysis they are joined by terminal branches of numerous metaphyseal and epiphyseal arteries. The former are direct branches of neighboring systemic vessels, the latter come from periarticular vascular arcades formed on non-articular bone surfaces. Numerous vascular foramina penetrate bones near their ends, often at fairly specific sites; some are occupied by arteries, but most contain thin-walled veins. Within bone, the arteries are unusual in consisting of endothelium with only a thin layer of supportive connective tissue. The epiphyseal and metaphyseal arterial supply is richer than the diaphyseal supply. The epiphyseal and metaphyseal arteries exceed the diaphyseal supply when the nutrient artery is destroyed. In immature long bones the supply is similar, but the epiphysis is a discrete vascular zone.[1]

Most of the studies on the vascular supply of long bones are done on the nutrient foramen, but very few studies are done on the vascular foramina at the ends of the long bone. Rogers and Gladstone (1950)[2] studied the

Author's Affiliation: *Junior Resident-III, **Associate Professor, ***Professor & Head, ****Junior Resident-II, Department Of Anatomy, Dr. V. M. Government Medical College, Solapur, Maharashtra.

Reprint's request: Dr. Harish A. Wankhede, Junior Resident-III, Department Of Anatomy, Dr. V. M. Government Medical College, Solapur, Maharashtra. Mobile no.: +919763403561

E-mail: drharrywan@gmail.com

(Received on 24.04.2013, accepted on 22.05.2013)

]vascular foramina and arterial supply of distal end of the femur in human. They concluded that vessels passing through vascular foramina at the ends of the long bones play an important role in the blood supply of the bone and prevention of ischemic necrosis in the distal end of femur. Tandon (1964)[3] carried the study on the vascular foramina at the two ends of ulna of human and concluded that the upper end of the ulna has got more blood vessels passing into the bone than the lower end.

Present study is carried out for the morphological study on the vascular foramina at the ends of the ulna and the study of the nutrient foramen on the ulna.

Material and Methods

220 dried human adult ulnas were studied. 101 ulnas belong to right side and 119 belong to left side. Age and sex were not defined. Length of the ulna was measured on the osteometric board. The vascular foramina at the upper and lower ends of the ulna were observed and numbered. Those foramina which admitted a metal wire of diameter 0.5 mm were designated as large and other as small.[3]

The vascular foramina at the upper end of the ulna were classified into the four groups:

1) Superior group- foramina on the superior surface of the olecranon process.
2) Anterior group- foramina on the anterior surface of coronoid process.
3) Medial group- foramina on the medial aspect of the medial surface of the olecranon and coronoid process.

Fig 1: Foramina on superior surface

Fig 2: Foramina on anterior surface

Fig 3: Foramina on lateral surface

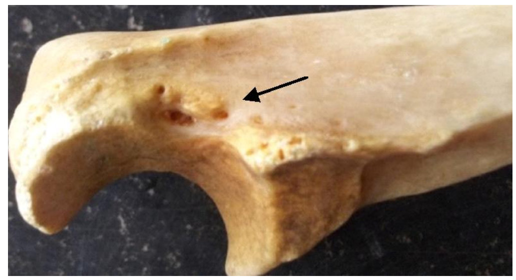
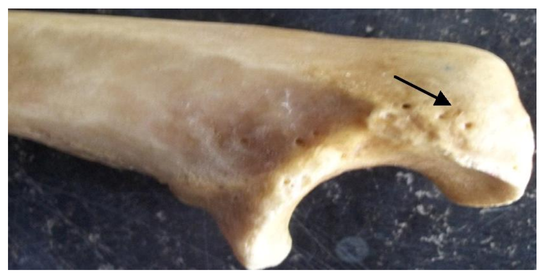


Fig 4: Foramina on medial surface



4) Lateral group- foramina on the lateral surface of the olecranon and coronoid process.

The vascular foramina at the lower end of the ulna were classified into the two groups:

1) Superior group- foramina on all aspects of the lower end of ulna except the inferior surface.
2) Inferior group- foramina on the inferior surface of the lower end.

Unpaired t-test was used for the difference between two groups; i.e. vascular foramina at the upper and lower end of the ulna.

The nutrient foramina were identified by the presence of a well-marked groove and slightly raised edge at the commencement of the canal.[4] Distance of the nutrient foramen from the upper end of the ulna was noted. Location

Fig 5: Foramina on superior surface

Fig 6: Foramina on inferior surface

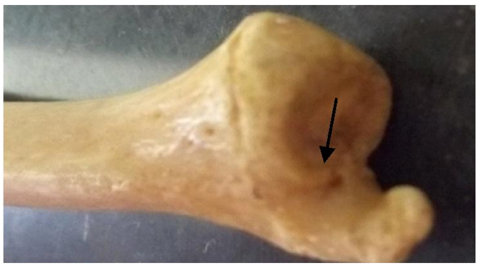


Fig 7: Nutrient foramina on the antero-medial surface of the ulna.

of the foramen was classified topographically into 1/5th, 2/5th, 3/5th, 4/5th and 5/5th part from the upper end of the ulna.

Results / Observations

Following observations were noted:

Mean value of the vascular foramina at the upper end of the ulna is given in table 1 and range is given in table 2.

Table 1: Showing distribution of the vascular foramina on the upper end of the ulna

Surface of the bone	Large vascular foramens (Mean ± S.D.)		Small vascular foramens (Mean ± S.D.)	
	Right	Left	Right	Left
Superior	1.03 ± 0.93	1.15 ± 1.07	2.6 ± 1.7	2.27 ± 1.48
Anterior	0.70 ± 1.13	0.28 ± 0.67	4.64 ± 2.47	4.5 ± 2.47
Medial	1.93 ± 1.15	1.93 ± 1.11	4.78 ± 2.14	4.81 ± 2.34
Lateral	0.45 ± 0.74	0.48 ± 0.72	3.62 ± 1.82	3.62 ± 1.76
Total mean	1.02 ± 0.64	0.96 ± 0.74	3.91 ± 1.01	3.8 ± 1.13

Table 2: Showing range of vascular foramens on the upper end of the ulna

Surface of the bone	Large vascular foramens (Range)		Small vascular foramens (Range)	
	Right	Left	Right	Left
Superior	0-4	0-6	0-8	0-8
Anterior	0-6	0-4	1-12	0-11
Medial	0-5	0-5	1-12	0-12
Lateral	0-3	0-3	1-10	0-12

Table 3: Showing distribution of the vascular foramina on the lower end of the ulna

Surface of bone	Large foramen (Mean ± S.D.)		Small foramen (Mean ± S.D.)	
	Right	Left	Right	Left
Superior	0.11 ± 0.43	0.01 ± 0.12	4.35 ± 1.96	4.47 ± 2.1
Inferior	0.51 ± 1.18	0.43 ± 0.74	0.9 ± 0.95	0.98 ± 0.99
Total mean	0.31 ± 0.28	0.22 ± 0.29	2.62 ± 2.43	2.72 ± 2.46

Table 4: Showing range of the vascular foramina on the lower end of the ulna

Surface of bone	Large foramen (Range)		Small foramen (Range)	
	Right	Left	Right	Left
Superior	0-3	0-1	0-10	1-14
Inferior	0-8	0-4	0-4	0-4

Table 5: Showing the topographical distribution of the nutrient foramina in the ulna

Topographical position of nutrient foramina	Right	Left	Total
1/5th	0.9%	-	0.45%
2/5th	67.3%	79.8%	74.09%
3/5th	37.6%	24.3%	30.45%
4/5th	-	-	-
5/5th	-	-	-

Mean value of the vascular foramina at the lower end of the ulna is given in table 3 and range in table 4.

Unpaired t-test was applied for comparison of difference between two groups; i.e. vascular foramina at the upper end and the lower end of the ulna. t-test value for larger vascular foramina on right side is 10.16, $p<0.01$ (highly significant) and on left side is 10.11, $p<0.01$ (highly significant). t-test value for small vascular foramina on right side is 4.90, $p<0.01$ (highly significant) and on left side is 4.33, $p<0.01$ (highly significant). It shows that the difference between the number of vascular

Table 6: Comparison between previous and present study on the vascular foramina on the upper end of the ulna (Mean ± S.D.)

Study		Superior surface		Anterior surface		Medial surface		Lateral surface	
		Large	Small	Large	Small	Large	Small	Large	Small
Tandon (1964)	Right	2.58 ± 0.98	2.37 ± 0.99	3.45 ± 1.09	7.14 ± 1.4	2.52 ± 0.9	4.73 ± 1.26	4.29 ± 1.18	9.36 ± 1.8
	Left	2.56 ± 1.11	2.32 ± 0.98	3.45 ± 1.11	7.23 ± 1.4	2.63 ± 0.95	5.15 ± 1	4.3 ± 1.06	9.8 ± 1.28
Present study	Right	1.03 ± 0.93	2.6 ± 1.7	0.70 ± 1.13	4.64 ± 2.47	1.93 ± 1.15	4.78 ± 2.14	0.45 ± 0.74	3.62 ± 1.82
	Left	1.15 ± 1.07	2.27 ± 1.48	0.28 ± 0.67	4.5 ± 2.47	1.93 ± 1.11	4.81 ± 2.34	0.48 ± 0.72	3.62 ± 1.76

Table 7: Comparison between previous and present study on the vascular foramina on the lower end of the ulna (Mean ± S.D.)

Study		Superior surface		Inferior surface	
		Large	Small	Large	Small
Tandon (1964)	Right	0.03 ± 0.18	1.61 ± 0.81	5.24 ± 0.85	0.35 ± 0.74
	Left	0.01± 0.12	1.78 ± 0.85	5.29 ± 0.9	0.43 ± 0.81
Present study	Right	0.11 ± 0.43	4.35 ± 1.96	0.51 ± 1.18	0.98 ± 0.99
	Left	0.01± 0.12	4.47 ± 2.1	0.43 ± 0.74	0.43 ± 0.81

foramina at the upper and lower end of ulna is highly significant.

Topographical distribution of the nutrient foramina is shown in table 5.

Discussion

Tandon (1964)[3] carried the study on the vascular foramina at the two ends of ulna of human and concluded that the upper end of the ulna has got more blood vessels passing into the bone than the lower end. Present study findings also shows that the number of vascular foramina at the upper end are numerous than that on the lower end. And small vascular foramina exceed the larger foramina on both ends of ulna.

Murlimanju et al. (2011)[4] conducted the study on the nutrient foramina on the ulna. The topographical distribution of the nutrient foramina on the ulna shows that in most of the bones the nutrient foramina is located on the upper 2/5th part of the ulna and few on the upper 3/5th part. In present study also similar findings were found.

Table 8: Comparison between previous and present study on the topographical distribution of the nutrient foramina on the ulna

Topographical distribution	1/5th	2/5th	3/5th	4/5th	5/5th
Murlimanju et al. (2011)	-	83.6%	16.4%	-	-
Present study	0.45%	74.09%	30.45%	-	-

Study done by Vinay and Kumar (2011)[5] topographically divides the ulna into three regions upper 1/3rd, middle 1/3rd and lower 1/3rd. In right sided ulna 50% nutrient foramina was located in upper 1/3rd and 50% in middle 1/3rd and in left sided ulna 38.9% was in upper 1/3rd and 61.1% in middle 1/3rd part of the ulna.

Giebel et al. (1997)[6] studied the arterial supply of the forearm bones to access vessels suppling it and for choice and position of implant to minimize vascular damage since the operative exposure of a fracture causes disturbances in the blood supply, which often leads to a prolonged process of healing or even healing problems like fracture non-union, which is frequently located at the forearm.

Greene (2006)[7] has quoted that variety of causes lead to non-union but most commonly, it can be attributed to disturbance in vascularity or inadequate stability.

Maheshwari (1997)[8] has quoted that the fracture of ulnar shaft at the junction of middle and lower-thirds is prone to delayed and non-union. Impairment of blood supply to the fragments of fractured bone is one of the contributory factors for non-union.

Conclusion

The present study concludes that the number of vascular foramina at the upper end of the ulna exceeds the foramina on the lower end and also the topographical distribution of the nutrient foramina is greater on the upper 2/5th part of the ulna. So, it shows that the upper end of the ulna has rich blood supply than the lower end. Therefore the lower end is more liable for ischemic necrosis, non-union and delayed union when get fractured. Also intra-medullary nailing for fixing fracture can damage the nutrient artery; in such cases vasculature at end of the bone plays an important role in the supply of nutrition.

Therefore the knowledge of such vascular foramina at the end of long bone is important to clinicians, surgeons and anatomist in the present era of modern surgeries like microvascular bone grafting and also in conventional surgeries like internal fixation by intra-medullary nailing to preserve the vascular supply of bone.

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