Original article

Internal thoracic artery: sternal branches and their importance in thoracic surgery

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Abstract

In surgical myocardial revascularization using both ITAs occurs a decrease in blood supply to the sternum and it is one of the causes of postoperative mediastinitis. Our study focused the sternal branches, from these ITAs, which are responsible for maintaining blood supply of the sternum after bilateral use of internal thoracic artery in myocardial revascularization. 60 internal faces of the anterior chest wall were dissected and formaldehyde preserved. The study consisted of 28 females and 32 males, the trunks and their branches were measured and photographed and statistical tests were applied. The most dissected sternal trunks found in 120 internal thoracic artery were the intercostal/sternal and the perforating/sternal. The preservation of these trunks is needed to prevent any disorder of the sternum.

Keywords: internal thoracic artery, sternum, blood supply, anatomy.

1 Introduction

In some surgical myocardial revascularization (SMR) when using both internal thoracic arteries (ITAs), it can be the cause of mediastinitis, since for a period of time the sternum is not able to receive an adequate blood supply to maintain its tissue activity and prevent the action of bacterial agents (GRAEBER, 1992; MANSOUR, THOURANI, ODESSEY et al., 2003, GUARAGNA, DALL'ALBA, GOULART et al., 2008). More than a century later, there is still no ideal conduct for the treatment of sternal wound infection, due to the bilateral use of ITAs, the great challenge for cardiac surgeons (VANDER SALM, OKIKE, PASQUE et al., 1989; VASKA, 1993; FRANCEL, KOUCHOUKOS, 2001; MORESCHI, MACEDO NETO, BARBOSA et al., 2008; TOCCO, COSTANTINO, BALLARDINNI et al., 2009).The preservation of sternal trunks, from the internal thoracic artery, has been indicated as a facilitator of maintaining the blood supply to the sternum thus hindering the inflammatory process (DE JESUS and ACLAND, 1995; PIETRASIK, BAKON, ZDUNEK et al., 1999, GRUPTA, SODHI and SAHNI, 2002; BERDAJS, ZÜND, TURINA et al., 2006).

The present study was focused to the sternal trunks, their distributions in the intercostal spaces in a way to prevent any possible disorder of this bone in revascularization surgeries with bilateral use of ITAs.

2 Method

An overall of 60 internal faces of the anterior chest wall were formaldehyde preserved, of which 28 females and 32 males, ages between 20 and 80 years (53.8 ± 16.2) from the service of verification of death (SVD) of Federal University São Paulo – Paulista School of Medicine. The research project was approved by the Ethics Committee of the Federal University of São Paulo under number: 0109/06 on 02/01/2006. The right internal thoracic arteries were injected with colored latex neoprene, a yellow color in the left internal thoracic arteries and the red in arteries on the right side. Trunks and sternal branches were dissected, measured, recorded and then photographed. Data were analyzed using the paired and unpaired *t* test between the sides, and the comparison between the number of branches in the intercostal spaces was found by means of Analysis of Variance (ANOVA), and in case of statistical significance in the comparison method, the Tukey´s multiple comparison test was used to determine which were different from each other (in pairs). It was also analized, using ANOVA test, the average of sterna trunk types in relation of gender. Statistical significance was established at 95%, that is, for values of *p* less than 0.05 ($p < 0.05$).

3 Results

120 internal thoracic arteries were dissected and an overall of 283 sternal trunks originated from them, of which 155 branches on the right side and 128 on the left. (Table 1)

In the dissections, we found four types of sternal trunks, the perforatings sternal (P/S), (figure 1) perforatings with anterior intercostal and sternal (P/IC/S) (Figure 2), anterior intercostals with sternal (IC/S) (Figure 3) and the posterior intercostal branches (IP) (Figure 4) continuations of the posterior intercostal with the anterior intercostals and sternal. We searched in 720 intercostal spaces (Table 2).

Where it was observed that the greatest number of branches were intercostal/sternal, followed by perforatings/sternal.

We described the type and number of trunks found from the first to sixth intercostal space in the 120 hemi sternum. (Table 3).

The type and number of trunks showed significant differences in the spaces ($p < 0.0001$), in the analysis by the Tukey´s technique that showed that the average of trunks in the second intercostal space was greater, followed by the first and third spaces. The most observed sternal trunks were the intercostal/sternal (IC/S) followed by the perforating branch/sternum (P/S).

A statistical analysis, alone, was performed regarding gender to observe if there were differences in the number of trunks. (Tables 4, 5).

A significant difference between genders was observed ($p < 0.0001$) regarding type of trunk, being the intercostal/sternal (IC/S) and the perforating/sternal more present in females and the intercostal/posterior (IP) in males (Tukey)

The sternal branches (Figure 2) of the trunks were distributed into three types in the intercostal spaces (Table 6).

The bifurcated, trifurcated or direct branches suffered anastomosis with the upper branch and/or with the inferior of the intercostal superior or inferior intercostal space forming in the margin of the sternum anastomotic arcades. These ipselateral anastomoses directed their small branches also to the anterior and/or posterior face the sternum (Figure 2). (Table 7).

The length of the sternal trunks, without specifying what type of trunk, was 0.1-8.0 mm (0.282 ± 0.220) on the

Table 1. Total of sternal trunks on the right and left sides in hemi-sternum.

Side	Sternal trunks		
	N	(%)	Mean (sd)
Right	155	54.7	(0.197 ± 0.425)
Left	128	45.3	(0.177 ± 0.410)
Total	283	100.0	(0.098 ± 0.319)

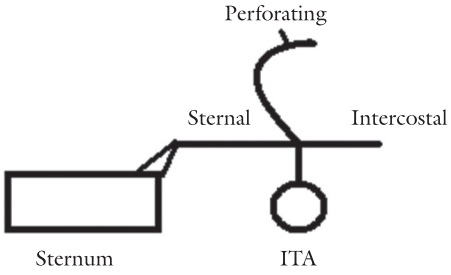

Figure 1. Trunk perforating intercostal sternal.

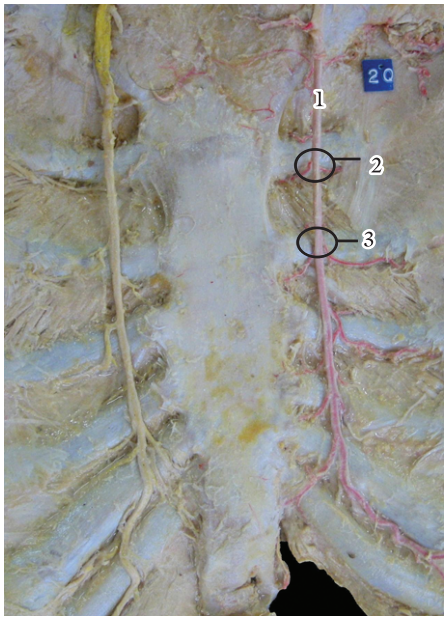

Figure 2. Bone sternum. 1) Internal thoracic artery-right side; 2, 3) trunk intercostal/sternal (IC/S).

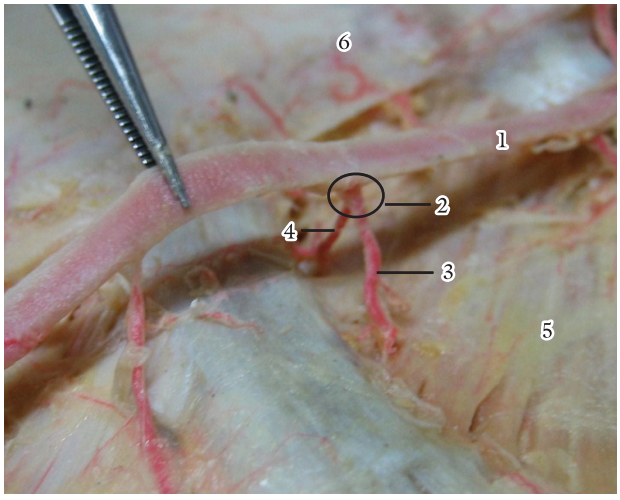

Figure 3. Sternum close. 1) Internal thoracic artery-right side; 2) trunk intercostal/sternal; 3) intercostal branch ; 4) sternal branch; 5) third space; 6) sternum.

Figure 4. schematic: Trunk Intercostal Posterior (IP).

Table 2. Number of four types of sternal trunks found in the 720 sternal intercostal spaces (the 120 hemi-sternum, 60 right and 60 left).

Type of sternal trunk	Total of intercostal spaces	Total of trunks	Standard deviation
Intercostal/sternal	720	135	0.187 ± 0.418
Posterior intercostal	720	12	0.016 ± 0.128
Perforating/sternal	720	113	0.154 ± 0.401
Perforating/intercostal/sternal	720	23	0.034 ± 0.183

Analysis of variance (ANOVA).

Table 3. Number of sternal trunks in the intercostal spaces of the hemi-sternum.

ICS	Sternal trunk	Number			Right and left
		N	Right	Left	Mean (sd)
1º	IC/S	120	12	11	0.191 ± 0.435
1º	PI	120	0	0	-
1º	P/S	120	19	17	0.300 ± 0.528
1º	P/IC/S	120	4	3	0.058 ± 0.235
2º	IC/S	120	11	12	0.191 ± 0.395
2º	PI	120	2	0	0.016 ± 0.128
2º	P/S	120	28	22	0.416 ± 0.602
2º	P/IC/S	120	9	3	0.100 ± 0.301
3º	IC/S	120	18	16	0.283 ± 0.505
3º	PI	120	3	1	0.033 ± 0.180
3º	P/S	120	9	8	0.141 ± 0.350
3º	P/IC/S	120	2	2	0.033 ± 0.180
4º	IC/S	120	20	18	0.316 ± 0.518
4º	PI	120	0	2	0.016 ± 0.128
4º	P/S	120	5	3	0.066 ± 0.250
4º	P/IC/S	120	0	2	0.016 ± 0.128
5º	IC/S	120	5	4	0.075 ± 0.264
5º	PI	120	3	1	0.033 ± 0.180
5º	P/S	120	0	0	-
5º	P/IC/S	120	0	0	-
6º	IC/S	120	5	3	0.066 ± 0.250
6º	IP	120	0	0	-
6º	P/S	120	0	0	-
6º	P/IC/S	120	0	0	-
Total			155 (0.107 ± 0.331)	128 (0.088 ± 0.305)	283 (0.098 ± 0.319)

t-test and ANOVA. Caption: ICS = Intercostal Space; N = Number; SD = Standard deviation; IC/S = Intercostal/Sternal; P = Posterior intercostal ; P/S = Perforating/sternal; P/IC/E = Perforating/intercostal/sternal.

Table 4. Average in relation to type of sternal trunk in males.

Type of sternal trunk	Male	
	N	Mean (sd)
IC/S	64	1.031 ± 0.755
PI	64	0.140 ± 0.350
P/S	64	0.859 ± 0.663
P/IC/S	64	0.171 ± 0.380
Total	256	100%

ANOVA test.

Table 5. Average in relation to the type of sternal trunk in females.

Type of sternal trunk	Female	
	N	Mean (sd)
IC/S	56	1.232 ± 0.687
PI	56	0.053 ± 0.227
P/S	56	1.035 ± 0.737
P/IC/S	56	0.214 ± 0.414
Total	224	100%

ANOVA test.

right side and 0.1-7.0 mm (0.243 ± 0.220) of the left, no significant difference (p = 0.057) (paired *t* test) was observed.

Gender analysis showed that in males it was 0.1-8.0 mm (0.390 ± 0.223) and in females from 0.1-3.2 mm (0.117 ± 0.087), the difference between sexes was significant (p < 0.0001).

4 Discussion

Our results showed that the intercostal trunk/sternal (IC/S) was found in greater quantities than in the other three types of sternal trunks, the IC/S emits a branch to the intercostal space and the other to the sternum, Pietrasik, Bakon, Zdunek et al. (1999) also reported it as the most common trunk.

In each intercostal space differences were found regarding the type and number of trunks in each intercostal space of the hemi sternum (DE JESUS and ACLAND, 1995; BERDAJS, ZÜND, TURINA et al., 2006).

The greater number was found in the second intercostal space (DE JESUS and ACLAND, 1995; PIETRASIK, BAKON, ZDUNEK et al., 1999; GUPTA, SODHi and SAHNI, 2002) and/or third space (PIETRASIK, BAKON, ZDUNEK et al., 1999; BERDAJS, ZÜND, TURINA et al., 2006). We found the greater number of them in the second and first intercostal spaces followed by the third, of which in the second we found the perforating/sternum which is in accordance with the study by De Jesus and Acland and similar to Gupta, Sodhi and Sahni. It is also described that

Table 6 . Type of distribution of the sternal branches to the sternum.

Type of distribution	Right side	Left side	p value
Bifurcation	93 (1.550 ± 0.501)	79 (1.317 ± 0.503)	p = 0.006
Trifucation	47 (0.783 ± 0.667)	39(0.650 ± 0.605)	p = 0.125*
Direct	15 (0.250 ± 0.436)	10 (0.166 ± 0.375)	p = 0.139*

*= p non significant

Table 7. Types of anastomoses of the sternal branches after bifurcation, trifurcation or direct.

Sternal branches	Right side		Left side		Total	
	N	(%)	N	(%)	N	(%)
Superior/inferior	109	71.8	92	70.2	201	71.0
Anterior/posterior	10	6.6	8	6.1	18	6.4
Posterior	31	20.3	30	23	61	21.5
Anterior	2	1.3	1	0.7	3	1.0
Total	152	100.0	131	100.0	283	100.0

the perforating / sterna is more present in the first and third space (PIETRASIK, BAKON, ZDUNEK et al., 1999).

The intercostal t/sterna trunk, in myocardium revascularization surgeries, using bilateral internal thoracic arteries, is anatomically evidenced as the one which maintains the blood supply to the sternum due to the connection between the sternal and intercostal branch (DE JESUS and ACLAND, 1995; HENRIQUEZ-PINO, GOMES, PRATES et al., 1997; BERDAJS, ZÜND, TURINA et al., 2006). We found the intercostal trunk/sterna (IC/S) in all intercostal spaces, and the greater number of these trunks was in fourth space, Berdajs, Zünd, Turina et al. (2006) described a similar result to ours. Other studies (DE JESUS and ACLAND, 1995; PIETRASIK, BAKON, ZDUNEK et al., 1999) did not find this trunk in all intercostal spaces.

The triple trunks, perforating / intercostal / sternal, in which the perforating branches gave off to an intercostal branch and another sternal, similar to that described by Berdajs, Zünd, Turina et al. (2006) and Pietrasik, Bakon, Zdunek et al. (1999), were more observed in the second intercostal space. The preservation of these trunks might also keep the blood supply to the sternum, when needed to be used bilaterally by the ITAs.

The posterior intercostal trunk (PI) was found in smaller number, agreeing with the results of De Jesus and Acland and diverging to Gupta, Sodhi and Sahni. that found greater number than ours. The presence of this IP trunk ensures constant supply of blood to the sternum as this vessel is independent of the internal thoracic artery (DE JESUS and ACLAND, 1995; GUPTA, SODHI and SAHNI, 2002).

Due to the statistical significance with regard to gender to human anatomy and for surgery, we analyzed the trunks in different sexes and noted that the perforating/sternal was more present in females and the intercostal/sternal in males.

Our results also showed that most of the sternal branches had bifurcated before reaching the sternum. The bifurcated, trifurcated and the direct sterna branches suffered an anastomosis with the next superior branch and/or the inferior intercostals space forming in the margin of the body an anastomotic arcade, as already described in other studies (ARNOLD, 1972; SICK, OBERLING and GUERBAQUI, 1974; BERDAJS, ZÜND, TURINA et al., 2006). The sternum has a dense arterial plexus to maintain its bone structure well irrigated (ARNOLD, 1972). The sternal trunks vary in length by 12 mm (DE JESUS and ACLAND, 1995; GUPTA, SODHI and SAHNI, 2002). The sternal trunks vary in length by 12 mm (DE JESUS and ACLAND, 1995, GUPTA, SODHI and SAHNI, 2002).

The difference in our study is that the female sex has longer lengths than males.

5 Conclusion

The intercostals/sterna followed by perforatings/sterna branches, both internal thoracic arteries trunks, were the most observed trunks in the second intercostal space. Their preservation should be necessary to keep the blood flow of the sternum bone when use both internal thoracic arteries in surgical myocardial revascularization intervention.

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