Change of sternal perfusion following preparation of the internal thoracic artery – a scintigraphical study

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Abstract

Background: Today the internal thoracic artery (ITA) is the bypass graft of choice due to its superior long-term patency rate. It was the aim of this present prospective study to investigate possible perfusion disturbances and consecutive impaired wound healing induced by the ITA preparation. The sternal perfusion was assessed by bone scintigraphy.

Methods: Forty-four patients were included in the study. There were three groups: group I (control, no ITA preparation; n = 12); group II (preparation of the left ITA; n = 21); group III (preparation of both ITAs; n = 11). In all patients a median sternotomy was performed. A bone scintigraphy was performed 4 days before and 12 days after the bypass procedure. Scintigraphical pictures of all patients were assessed visually (one specialized investigator) and the impulse rate was counted by the aid of a computer program.

Results: Results of both evaluation methods showed congruently that neither the use of the left nor of both ITAs causes a statistically significant impairment of sternal perfusion. The percentage of postoperative increase of the rate of impulses was in group I: total sternum 55%; right side 56%; left side 55%. The respective numbers for group II were 58, 63 and 53 %, and for group III 54, 52 and 56%. Surprisingly, perfusion scans in group II revealed an increase in the right sternal half after left ITA preparation. This may be due to the additional blood flow demand of collaterals branching between the right ITA and contralateral intercostal arteries representing a compensatory mechanism of the loss of the left ITA. During the observed postoperative time frame (mean 15 days) no healing disturbance of the sternal wound occurred in any patient.

Conclusion: According to the present data the use of one or both ITAs does not cause an increase of healing disturbances, consecutive to a postoperatively decreased sternal blood perfusion.

Keywords: ITA preparation; Sternal scintigraphy; Postoperative sternal blood supply; Deep sternal wound infection

1. Introduction

Sternal infection and mediastinitis after median sternotomy is a deleterious complication. Whether sternal infection is related to dissection of one or both internal thoracic arteries is a matter of controversy [1,2]. The combined mortality and morbidity of such a dreadful complication like deep sternal wound infection could possibly neutralize the potential benefit of double ITA. As a contribution to this discussion we performed a prospective study to measure sternal perfusion pre- and postoperatively by bone scintigraphy in order to evaluate possible perfusion disturbances or defects.

2. Patients and methods

Forty-four patients were included in the present study, 38 were male and six female, the age being 55 years in the mean (range 38–74 years). The patients were divided into three groups according to the surgical technique used: in group I, the control group, no ITA preparation was performed; this group comprised 12 patients, eight male and four female with an age of 55 years; all 12 patients received vein grafts, five of them an additional valve replacement.

Group II comprised 21 patients, 19 male and two female with a mean age of 56 years. In all 21, preparation of the left ITA was performed: four patients received one additional vein graft and seven patients received two additional vein grafts.

Group III comprised 11 male patients with a mean age of 53 years. In all 11 patients of this group both ITAs were


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prepared. In all 44 patients a median sternotomy was performed. Patients with diabetes mellitus or having a neoplasia were excluded from the study.

2.1. Perioperative protocol

All patients were submitted to the same protocol before operation: search for possible infection (especially of dental, respiratory, and genitourinary origin), shaving of the operative site, and showering with an antiseptic soap. Prophylactic antibiotic treatment (cefazolin) treatment was started at the induction of anesthesia and continued during 48 h at doses of 2 g every 8 h.

2.2. Radionuclide imaging

A bone scintigraphy was performed 4 days before and 12 days after the bypass procedure. The radioactive marked 99m-Tc-technetium-diphosphonopropan-dicarboxylacid were used as indicator. The three-phase bone scintigraphy used involves the perfusion-phase (up to 60 s), the bloodpool-phase (up to 10 min), and the mineral- and bone-phase (2–3 h). The scintigraphical pictures were shot during the last mentioned bone-phase. All scintigraphical pictures were assessed visually by one specialized investigator according to the following criteria: (a) homogeneity of whole sternal uptake, (b) comparing judgement of both sternum halves, (c) judgement of the anatomical segments of the sternum and (d) midline uptake after median sternotomy.

In addition a numeric evaluation was done by counting the impulse rate with the aid of a computer program; to do this eight sites for measurement were defined: the sternum as the region of interest (ROI) were divided into six parts. The cervical spine was the reference region (ref-ROI), because this region was not involved in the operation, count rate of this region was set to 100%. The listed counts in Table 1 are the difference of mean values pre- and postoperatively.

3. Results

The three groups of patients were similar with respect to age, sex, incidence of obesity, reexploration for bleeding, and averaged clamping and cardiopulmonary bypass times. Extent of coronary artery disease and left ventricular function were also similar among the three groups.

3.1. Visual evaluation

The scintigraphical pictures of all 44 patients were evaluated visually. Comparison of the preoperative and postoperative pictures revealed an unaltered homogenous uptake in a high percentage of the cases postoperatively. The numbers are listed in Table 2. There was no significant difference between the two halves of the sternum. As an example the pre- and postoperative scintigraphical pictures of one case is shown in Figs. 1 and 2.

3.2. Numerical evaluation

In Table 1 the increase of the impulse rate expressed as a percentage is listed. Group I (control) showed an increase of 55% in the total sternum. Uptake distribution was homogenous. In group II (left ITA) an increase of 58% was registered. This increase was more pronounced in the right lateral half of the sternum. After preparation of both ITAs (group III) the increase was 54% with a slight tendency to a lower increase in the right half.

The visual as well as the numerical evaluation revealed in 4 patients an inhomogenous radioactive uptake. During the postoperative time frame of 15 days no healing disturbances were observed in any patient.

4. Discussion

The main finding of this study was that there was no decrease of sternal blood supply after preparation of the

Table 1
Numerical evaluation: postoperative percentage increase of the impulse rate in the three groups compared with preoperative

<table>
<thead>
<tr>
<th>Sternum</th>
<th>Group I (control) (%)</th>
<th>Group II (left ITA) (%)</th>
<th>Group III (both ITA) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>55</td>
<td>58</td>
<td>54</td>
</tr>
<tr>
<td>Right half</td>
<td>56</td>
<td>63</td>
<td>52</td>
</tr>
<tr>
<td>Left half</td>
<td>55</td>
<td>53</td>
<td>56</td>
</tr>
<tr>
<td>ST1*</td>
<td>63</td>
<td>65</td>
<td>53</td>
</tr>
<tr>
<td>ST2*</td>
<td>55</td>
<td>63</td>
<td>62</td>
</tr>
<tr>
<td>ST3*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* ST1, manubrium; ST2, corpus; ST3, distal sternum.

Table 2
Visual evaluation of the sternum: comparison of the three groups

<table>
<thead>
<tr>
<th>Sternum</th>
<th>Group I (control)</th>
<th>Group II (left ITA)</th>
<th>Group III (both ITA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>42</td>
<td>47</td>
<td>58</td>
</tr>
<tr>
<td>Right half</td>
<td>50</td>
<td>63</td>
<td>67</td>
</tr>
<tr>
<td>Left half</td>
<td>58</td>
<td>47</td>
<td>75</td>
</tr>
<tr>
<td>ST1 rightb</td>
<td>92</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>ST1 leftb</td>
<td>92</td>
<td>95</td>
<td>92</td>
</tr>
<tr>
<td>ST2 rightb</td>
<td>67</td>
<td>95</td>
<td>92</td>
</tr>
<tr>
<td>ST2 leftb</td>
<td>75</td>
<td>84</td>
<td>100</td>
</tr>
<tr>
<td>ST3 rightb</td>
<td>58</td>
<td>68</td>
<td>75</td>
</tr>
<tr>
<td>ST3 leftb</td>
<td>58</td>
<td>47</td>
<td>75</td>
</tr>
</tbody>
</table>

* The values (%) represent the postoperative unaltered homogenous uptake in a high percentage of the cases.

b ST1, manubrium; ST2, corpus; ST3, distal sternum.
left ITA or even both ITAs. The postoperative increase of sternal blood perfusion is explained by an increased blood supply via collaterals. This phenomenon was previously described by Arnold [3] in 1972. The postoperative increase of uptake postoperatively corresponds with the hyperemia during bone healing. This finding is in contrast to a recent publication of Carrier et al. [4]. They reported a significant partial and temporary sternal ischemia assessed by sternal technetium-99m-methylene diphosphate tomography following ITA dissection. In contrast to the present study there was no comparison between preoperative and postoperative tomograms and there was only assessment by visualization. These differences in the study design may explain the different findings.

Only comparison of the pre- and postoperative findings allows reliable statements about a significant changed radioactive uptake. In the present series there were few cases presenting with an inhomogenous uptake preoperative, such that a correspondingly poor postoperative scan would have mislead the investigator.

Because of the clinical significance of sternal infection there are several publications dealing with this subject [5,6]. On the one hand Cosgrove et al. [7] by multivariate logistic regression analysis did not identify bilateral ITA grafting as a risk factor for wound complications, on the other hand Grossi et al. [1] reported an increased infection rate after ITA grafting, especially after use of double mammary artery grafts in the presence of diabetes. Probably by chance not any case of sternal infection developed in the present series. The findings of this study are supported by a statement of Grmoljez and Barner [8] who found that bilateral ITA mobilization does not result in avascularity of the sternum. Moreover, if impaired sternal blood supply were responsible for the infection, prompt healing of the sternum would not be anticipated in general. As early as in 1976 Culliford et al. [9] stated that consideration of general surgical atraumatic principles are of outstanding importance. Their review of 2594 cases of open-heart surgery showed that most of the occurring infections were associated with a number of predisposing factors: prolonged perfusion time, excessive postoperative bleeding, depressed cardiac output in the postoperative period, and a history of re-exploration for the control of hemorrhage. In addition, prolonged use of inotropic support was another risk factor for deep sternal wound infection in the Parisian Mediastinitis Study [5].

There is a long line of evidence that the risk of sternal infection is increased in the presence of diabetes [2,10–12]. Especially diabetic micro- and macroangiopathy and the autonomous diabetic neuropathy and the consecutive heart rhythm disturbances and heart failure lead to a reduced cardiac output, which may support wound healing problems [13]. Those patient-related risk factors like diabetes cannot be modified. However, procedure-related variables like operating room policies and operative techniques can be changed, with a rewarding influence on results [6].

4.1. Critique of methods

In the present series patients with diabetes were excluded. This was done to avoid confusion in interpreting the obtained results. On the other hand diabetes is present with a high incidence in coronary patients. As it is related to wound healing disturbances a series including diabetes...
patients could show different results than those presented here. Increasing the total number of investigated patients would allow a more valid statistical evaluation of the clinical outcome. This study was designed to show the basically sufficient blood supply after conventional harvesting of the ITAs.

The quality of the visual evaluation of the tomograms is highly dependent on the experience of the specialist, which was single in this study. Perhaps only the computer-aided results are needed.

5. Summary and conclusion

According to the data of the present study and to the available special literature there is no significant reduced sternal blood supply after preparation of the ITAs. In conclusion ITA dissection itself does not cause an increased risk of sternal infection.

References


Appendix A. Conference discussion

Dr D. Keenan (Manchester, UK): Is the test that you did sensitive enough to pick up subtle changes which might occur?

Dr Korbmacher: Yes, there were subtle changes in a few patients, exactly in four patients. In four patients there was a inhomogeneity, but if you count the whole uptake, you have a very homogenous distribution in all the remaining 40 patients.

Dr A. El Gamal (London, UK): The radioisotopes have been taken by white cells and how you differentiate perfusion from inflammation in the sternum in the early postop. You can have increased radiation just because white cells are there, but that doesn’t mean that the bone is perfused, because a lot of white cells will catch up on the marker. What do you say for that?

Dr Korbmacher: Yes, that is obviously a very good question, but I think the advantage of this study was that we did perform the same study technique pre- and postoperatively, and I think one cannot exclude that this hyperemia is done by a kind of inflammation. But in my opinion, the findings are not so surprising, because I think this postoperative hyperemia is very common if you set any injury in the body, and of course, this was done 12 days after the operation, that means after the end of wound healing, and therefore I think it is reliable.

Dr El Gamal: I am not discussing the reliability of the test, but usually when we even suspect infection in the sternum, we will do the same test, and if there is an increased uptake in one area, you suspect there is a collection of white cells there and there is an infection in the bone. So I am just concerned that maybe what we see is increased uptake. It is not due to increased perfusion, but there are white cells there because there is inflammation, and how can you differentiate between both?

Dr Korbmacher: Yes, but then I think we would have additional clinical signs of inflammation and real great inhomogeneity in the scan. As I showed you, there is a real homogenous uptake of this scintigraphical activity.

Dr A. Hurle (Barcelona, Spain): There are a couple of questions I would like to ask you. First of all would be regarding the technique. Were these mammarys harvested as pedicled grafts or as skeletonized grafts?

Dr Korbmacher: Yes, pedicled grafts.

Dr Hurle: Now the second question is that you performed the isotope scan 12 days in the postoperative period. Now, we know by experience that if a patient is to have a sternal dehiscence, it usually happens earlier than that; probably within the first week or so the dehiscence has already shown up. In other words, if the patient gets to the 12th day without having any sternal dehiscence, it is likely that the blood supply to his sternum is okay, and that would be consistent with your results. I was wondering whether you would probably have gotten more relevant findings if you had performed the scintigraphy say on the third or fourth postoperative day?

Dr Korbmacher: Yes, I thought about this, and I think it is very important to mention it, but in our study the essential question was, if there is an increased blood supply after median sternotomy and after harvesting on the internal thoracic artery and it was not, is there a technique on the internal thoracic artery in all patients, but we haven't done this study in diabetic patients. But I think it is a good suggestion. Because of this very significant question, whether diabetes is a predisposing factor for deep sternal wound infection, one should do another study with diabetic patients who are, firstly, on oral and, secondly, on insulin medication.
Dr Rao: Nearly 50% of our patients are diabetics.

Dr E. Brackenbury (Edinburgh, UK): Clarify a point for me, please. One of the earlier questions went on about white cells as labeling up the sternum, but this is actually a conventional bone scan, is it not? You didn’t label white cells. It was a bonesearching isotope that was labeled and therefore was taken up by the crystalline matrix of bone, is that right? The technique of isotope bone scans you mentioned have three phrases, and you concentrated on the third phase. Just to clarify in my own mind, that phase isn’t to do with white cell uptake, is it? It is due to bony matrix uptake. Is that correct?

Dr Korbmacher: Yes, so I understand you that this confirms what I said.

Dr Brackenbury: Yes, so your increased uptake isn’t due to increased white cell infiltration of the bone. It is due to increased bony matrix being laid down, which is the principle of the bone scan, is that right?

Dr Korbmacher: Okay.