No change in $O_2$ saturation but measurable difference in thenar flexor power after radial artery harvest

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Received 23 September 1998; received in revised form 12 April 1999; accepted 13 April 1999

Abstract

Objectives: Objective measures of morbidity will be required to establish the radial artery (RA) as a viable long term alternative to saphenous vein. The RA is the dominant arterial supply to the thenar musculature. We hypothesised that RA harvest should decrease $O_2$ saturation and thenar muscle power.

Methods: RA was harvested from non-dominant (ND) limbs only ($n = 58$, right $n = 21$). Oximeter values of $O_2$ saturation were taken from the thumb of the dominant (D) and non-dominant (ND) limb pre and post operatively. A syringe filled with 25 cc of air is emptied against a one way valve connected to a pressure generator MX 100 by MEDEX, Inc, Ohio, USA. Three measures of thenar flexor power (TFP) were taken and mean values obtained in the ND and D limbs.

Results: $O_2$ saturation ranged from 92 to 98% in the thumb of the ND limbs 24 h post RA harvest. The values for TFP (mean ± SD) were $1246 ± 246$ mmHg (ND) and $1240 ± 258$ mmHg (D) pre-operatively and $1216 ± 250$ (ND) and $1259 ± 233$ (D) post operatively. The changes in TFP between the ND and D limbs ($37 ± 0.60$ ND and $1 ± 0.86$ D) were significant for the D against the ND limb ($P < 0.001$). This reduction in TFP for the harvested limb was also found when considering handedness ($28.0 ± 24.2$ and $40.3 ± 69.2$ for the left and right handed patients respectively).

Conclusion: Our findings confirm the hypothesis that there are objective differences in TFP pre and post RA harvest at 3 months. Further studies are required to assess the clinical significance and persistence of the loss of TFP.

Keywords: $O_2$ saturation; Thenar flexor power; Radial artery

1. Introduction

Total arterial revascularisation of coronary arteries is an attractive concept whose hope is to provide bypass conduits that remain patent longer than saphenous vein [1–3]. Although accepted for the internal mammary artery anastomosis to the left anterior descending artery, the use of arterial conduits at other sites in the heart remain controversial. The long term patency of the conduit becomes the limiting factor of the operation in an era where progression of distal disease in coronary arteries may be controlled or regressed by interventional therapies aimed at risk factors such as hypertension, hypercholesterolaemia and smoking. The radial artery is a readily accessible alternative conduit to saphenous vein whose initial studies proved unacceptable [4,5]. Improved harvesting techniques and handling of the conduits and surprising long term patency found by chance [6], have resurrected interest in this conduit for coronary artery bypass grafting operations. However concerns remain about the consequences of harvesting the RA, particularly the effect this may have on hand function.

Objective measures of morbidity will be required to establish the RA as a viable long term alternative to saphenous vein. As the RA is the dominant arterial supply to the thenar musculature [7], we hypothesised that the RA harvest should decrease $O_2$ saturation and thenar muscle power.

2. Patients and methods

2.1. Population sample

A prospective study of 79 consecutive patients (59 male and 20 female), undergoing elective and urgent coronary artery bypass grafting, whose RA was harvested from the non-dominant arm (L 58, R 21), was carried out. The mean age of the group was 63.7 years (range 34–80 years). The average number of grafts was 3.2 per operation. Myocardial protection was standardised blood cardioplegia and the
average cross clamp time was 22 min, with a bypass time of 45 min. All patients underwent extubation in the first 24 h period (range 6.4–14 h).

2.2. Surgical technique

The RA was harvested using a standardised technique in patients with a positive pre-operative Allen test. The adequacy of the ulnar collateral circulation was confirmed before harvesting the vessel by an operative technique which has been described in detail and submitted for publication.

2.3. O2 saturation

Pulse oximetry was used to determine the O2 saturation utilising a standardised monitor on the patients’ thumbs. These monitors are standard and in use routinely in intensive care and ward settings; they are used as a practical screen to indicate changes in digital O2 saturation. Each limb was compared with the other and measurements were obtained pre-operatively from the limb to be harvested, immediately after harvesting and after return to the intensive care unit. O2 saturation was determined continuously and recorded for 24 h post-operatively. Arterial blood gas sampling was performed at the time of any change in O2 saturation to determine if this was accurate.

2.4. Thenar flexor power

Most patients are either right or left handed in terms of daily usage, e.g. handwriting. Handedness refers to this pattern of activity with the dominant hand being that used for handwriting. A standard syringe filled with 25 cc of air is emptied by thumb flexion against a one way valve connected to a pressure generator (MX 100 by MEDEX, Inc Ohio USA). Three measures of thenar flexor power (TFP) were used to obtain a mean in mmHg. This was done for each limb of the patients, pre-operatively and at 3 months post operatively.

2.5. Statistical methods

Data in figures are expressed as the mean and SD. Pre-operative and post operative changes were analysed using a paired Student test.

3. Results

There were no deaths in the group and all patients underwent pre-operative and post-operative assessment.

3.1. O2 saturation

The range of O2 saturation measurements was 92–98%, pre- and post-operatively. No statistically significant change in digitally derived O2 saturation in the thumb or fingers was observed after RA harvest in the 24 h period other than that expected at the time of extubation. In all cases this returned to normal. In five patients who required inotropic support with vasoactive drugs (dopamine and adrenaline), there was no observed difference in O2 saturation pre- and post-RA harvest. Where a change in digitally derived O2 saturation was detected by the monitor, formal arterial blood gas analysis was performed and the values compared. In this study the changes detected by the monitor were the same as those detected but measured by arterial blood gas sampling. The changes in TFP between the ND and D limbs (37.0 ± 60.6 ND and 1.86 ± 65.9 D) showed a significant reduction in TFP for the D against the ND limbs (P < 0.001). This reduction in TFP for the harvested limbs was also found when considering handedness (28.0 ± 24.2 and 40.3 ± 69.2 for the left and right handed patients, respectively).

4. Discussion

The RA is the main blood supply to the flexor compartment of the forearm and the thenar musculature with the ulnar artery being the dominant supply to the hand [8,9]. The major anatomic connections that should allow safe harvest of the radial artery are the deep and the superficial palmar arch [10,11]. Because of the known anatomic variations that exist and the unreliability of the pre-operative measures to determine the effect the RA harvest might have in immediate devascularisation of the hand, we employed an intraoperative surgical technique that confirms immediate patency of the ulnar collateral circulation (submitted for publication). The hypothesis under test is that removal of the RA would result in immediate or chronic devascularisation which should have a significant effect on O2 saturation and on the flexor muscle power of the thenar emminence. As the thumb is perhaps the most important digit in the hand, objective measures to determine the effects of RA harvest are a prerequisite to establish the routine use of the RA as an alternative to saphenous vein. Our hypothesis was tested in a simple and standardised technique utilising O2 saturation and thenar flexor power as end point measures in a group of patients undergoing elective and urgent CABG with a standardised surgical procedure performed by one surgeon. The results show no change for each patient’s O2 saturation post RA harvest. O2 saturation monitors are in routine use in all aspects of intensive care management of patients and derive values on the skin surface implying the adequacy of the peripheral arterial blood supply and extraction of O2 at the tissue level. Formal arterial blood gas sampling is required to measure this change. The thenar emminence muscles are fast twitch muscles particularly susceptible to changes in O2 supply. Spurious results can be obtained when vasoconstriction or vasodilatation occurs. As this was checked for accuracy against arterial blood gas sampling in this study the result
obtained is likely to be accurate. Even in those patients in whom dopamine and adrenaline were given there was no significant effect. We have determined in this study that there is an objective measurable decrease in thenar flexor power post-RA-harvest in the immediate post-operative period which persists up to 3 months post harvest, compared to the thenar flexor power in the same patient’s non-harvested limb. However, there was no objective evidence of clinical significance (as this was not measured). One patient reported parasthesia over the dorsum of the thumb but did not complain of loss or interference with routine use of the digit.

In the post-operative period there are physiological reasons why muscles lose power which are related to catabolism. Non-dominant limbs are generally weaker to begin with, as has been demonstrated in this study. An alternative explanation is that the observed change is due to chronic ischaemia in this muscle group related directly to RA harvest. This is suggested by its persistence for up to 3 months and if this is the case then further studies will have to be done before the clinical significance of the change can be understood.

In summary, we have determined an objective decrease in TFP post-RA harvest in non-dominant limbs that persists for up to 3 months post-operatively using a standardised objective method of measurement. Further studies are required to determine whether this is clinically significant, and whether it is related to chronic ischaemia post-RA harvest.

References


Appendix A. Conference discussion

Dr R. Guti (Hyderabad, India): Do you have any exclusion criteria for this assessment of the decrease in the power of the flexor muscles, any brachial injuries and other things you have excluded in your study?

Mr Grossebner: Exclusion criteria for the actual test?

Dr Guti: Yes.

Mr Grossebner: Obviously patients who had any problems in their hands, either operation before or injuries which might contribute to a loss of power, were excluded, and in these patients there was no previously known problem with the function of the hand. So they obviously had to be able to do this test.

Dr Guti: Do you think removal of the radial artery alone caused decreased power in the thenar flexor muscles or injury to the surrounding cutaneous nerves produced the problem?

Mr Grossebner: We feel it is very obvious that this is due to the radial artery harvest. It has to be shown in the future whether this actually represents a chronic ischaemic problem or whether this is going to just improve with time, and we are obviously trying to follow these patients up for the year’s time to actually see whether this change persists or whether it all goes back to baseline, which we somehow suspect. We have not assessed that formally, but clinically there were no patients complaining in fact of loss of power. So it is only a measurement which we obtained. Nobody said they had a problem actually with the harvested side in terms of power loss.