EVALUATION OF THE PLEURAL DISRUPTION FOLLOWING COSTOCHONDRAL GRAFT HARVESTING FROM FOURTH TO SEVENTH RIBS OF ADULT MALE CADAVERS

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Abstract- Costochondral and rib grafts have long been used for reconstruction of lost condyle. Donor site morbidity has less been under investigation and researched. Pleural disruption pneumothorax and ugly scars are among the donor site complications. This study aims to determine the rate of pleural disruption following costochondral graft harvesting from the 4th to the 7th ribs of right and Left ribs from recently expired cadavers; so maxillofacial surgeons and thorax surgeons could spare high risk ribs and minimize post- operative complications. This interventional study was performed on 80 ribs from 32 adult male cadavers with the recorded death being within the last 24 hours and all free of pulmonary diseases. We harvested 80 costochondral grafts from 32 cadavers and the incidences of pleural disruption were examined for the 4th to the 7th ribs of right and left side by means of SPSS software (10 harvestings from each rib). The incidences of pleural disruption were 17.5% while the right fifth rib had the highest risk (30%) and the left fifth rib had the lowest risk (0%). For the fourth to seventh ribs there were no significant differences between the ribs for pleural disruption, (P = 0.95) either in the right or the left ribs (P = 0.24). Pleural disruption was more probable to exist under the chondral part of costochondral grafts (CCG) rather than the osseous part. Valsalva maneuver was more useful than the naked eye for diagnosis of pleural disruption.

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Key words: Costochondral graft, rib graft, pleural disruption, cadaveric study

INTRODUCTION

Grafts have long been used in reconstructive maxillofacial surgery. Costochondral and rib grafts are appropriate costochondral grafts (CCG) for reconstruction of defective or lost condyle. Initially, Gillies represented replacement of mandible condyle with costochondral graft in 1920. Surged applications include congenital dysplasia of condyle, deformity of condyle because of trauma, internal disease of bone or cartilage and osteoarthritis. The basis for using CCG in growing individuals has been the fact that condyle cartilage acts as the main growth center of mandible and proliferation of chondrocytes is considered to be essential for growth of the entire mandible. Later, Poswillo rejected the theory that CCG acts as a growth center and indicated that cartilage conforms to with environment and function (1).

Several articles have been presented about autogenous rib graft harvesting, its advantages and disadvantages, problems of grafted site and

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properties of this type of graft in specialized textbooks and journals of maxillofacial and plastic surgery have been published (2-4).

Although rib graft harvesting is recommended in treatment of ankylosis, reconstruction following tumor surgery, correction of jaw deformities and reconstruction of arthritic joints, the probability of graft overgrowth and undergrowth, repeated ankylosis, lack of appropriate adaptation of graft with glenoid fossa are also demonstrated as disadvantages of this graft (4).

Donor site injuries and problems have less been under research and investigation. Pleural disruption, pneumothorax, lack of breast growth and ugly scars are indicated as some of the complications in specialized textbooks about donor site (5, 6). In this research, efforts are made to study the donor sites of newly expired cadavers similar to grafted patients, based on pleural and pulmonary tissue variations, in order to distinguish the probability of pleural disruption following costochondral graft harvesting from fourth to seventh ribs of right and left side.

Applied aims of this study are as follows: 1) reduction of complications following rib harvesting with the knowledge that the lowest risk ribs are fourth to seventh; 2) reduction of complications following rib harvesting the left and right hand side of the rib cage have a higher risk factor a Hatched.

MATERIALS AND METHODS

In this uncontrolled interventional study, the newly expired cadavers where the tome of death was within the last 24 hours were utilized. As no other similar study has been carried out on cadavers yet, for determination of the number of sample, 32 rib harvestings were initially used as a pilot study. According to the obtained results, the number of samples increased or considered as sufficient. Indeed, according to 8 different types of ribs under study, 4 harvesting from each type of rib were carried out and pleural disruption was studied. In the pilot study, pleural disruption occurred in 1/8 of cases and using the following equation, the number of sample turns out to be 80 ribs, approximately:

$n = p(1-p)/d2=80$; where: $P=1/8$, $d=0.072$ and $=1.96$

The criteria for choosing cadavers were as follows: 1) male cadavers; 2) newly expired cadavers; 3) pulmonary diseases have not been the cause of death; and 4) there has not been thorax trauma.

The method used in this research was such that initially pectoral is muscle and other muscles which reside bilaterally on the chest were removed slowly with a vertical incision on the chest of cadaver from sternal notch region to the navel and dissecting skin on both sides of chest. Then, ribs are counted in the descending order to identify the rib. If there were any doubts in regard to the accuracy of the count process, a specified process on sternum in the region of second rib junction would be used. Subsequently, preserving a periosteochondral oblong in the region of costochondral junction, bilateral periostei and perichondrium were removed slowly with a longitudinal incision on rib and using periostei elevator, bone and cartilage were released slowly. Then 2, 5 cm of the bone was cut by a rib cutter, placing a malleable under cartilage, this was also cut in the size of 0.5 cm by blade. After that, the operation area was evaluated for pleural disruption by the naked eye and was filled with physiologic serum and then Valsalva maneuver is carried out so that pleural disruption was visible in the case of bubbles exiting from the area. Consequently, if pleural disruption did not exist, the next rib would be tested likewise. If pleural disruption occurred, the experiment on the next rib was avoided as the pleural vacuum system and its integrity would disrupt the accuracy of the next experiment.

The experiments on the next cadaver continued with the rib whose turn it was to be examined in the case of the previous cadaver but was not tested because of pleural disruption. Thos is so that biasness is avoided in this study. Finally, the initial vertical incision was sutured. The compiled data was entered in to the SPSS software program and then the amounts of pleural disruption were calculated based on the number of ribs and the side of the rib cage. Subsequently, the comparison between the above amounts was made according to Chi square statistical test and 2 variable statistical analyses were used to determine the least amount of pleural disruption among above ribs.

RESULTS

In this study, 80 ribs were harvested from 32 cadavers; the reasons for death of the individuals in the population mentioned in this study according to Figure 1 were as follows: 1) head trauma: 15 individuals; 2) addiction (drug overdose): 6 individuals; 3) internal diseases: 4 individuals; 4) stature trauma: 3 individuals; 5) gun shots: 2 individuals; and 6) CO toxicity: 2 individuals

The average ages of cadavers were 35 years and the table of age distribution of cadavers is shown in Figure 2. In 80 harvested ribs (10 harvesting from each rib), pleural disruption occurred 14 times in total (17.5 percent). The probability of pleural disruption of each rib is given in Figure 3.

So, the probability of pleural disruption following rib harvesting of fourth, fifth, sixth and seventh ribs was 20, 15, 15, and 20 percent, respectively. Likewise, the probability of pleural disruption following rib harvesting of the right and the left sides was 22.5 and 12.5 percent, respectively. The lowest risk rib was the left fifth rib (0 percent) and the highest risk rib was the right fifth rib (30 percent). In 14 cases of pleural disruptions, 2 cases were visible by the naked eye but were not verified by Valsalva maneuver (14 percent) and in 3 cases the reverse was true. In other words, disruption was not visible by the naked eye but was observed by Valsalva maneuver (21 percent). Nevertheless, whether was detected by the naked eye or by Valsalva maneuver solely or disruption both, presence of pleural disruption was confirmed. The site of pleural disruption was infrabony in 7 cases (50 percent), infrachondral in 5 cases (35 percent) and unknown in 2 cases (15 percent).

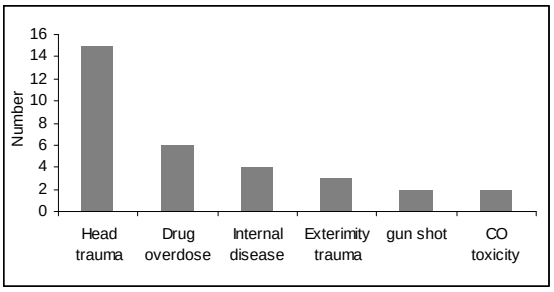

Fig.1. Distribution of the reasons of cadaver's death used in this study.

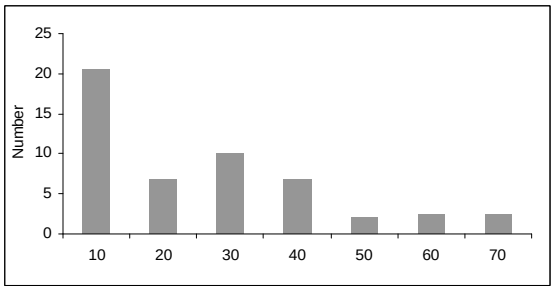

Fig. 2. The age distribution of cadavers.

The size of pleural disruption was not measurable in 5 cases. It was 42.5 mm^2 in average in 9 cases. In 80 cases of rib harvestings, the region of costochondral junction was disjoined in 2 (5 percent).

Chi square statistical test was carried out on the variables of the number of ribs and pleural disruption for investigation of the probability of pleural disruption following graft harvesting from the fourth to the seventh ribs and the result of this test was not statically significant with statistical value of 0.34 and freedom degree of 3 ($P = 0.95$). Chi square statistical test was carried out on the variables of the side of ribs and pleural disruption for investigation of the probability of pleural disruption following graft harvesting from right and left ribs and the result of this test was not statically significant with statistical value of 1.38 and freedom degree of 1 ($P = 0.24$).

A Valsalva maneuver chi square test was carried out between the variables of observation of the site of pleural disruption and verification of pleural disruption for investigation of the difference between observation of site of pleural disruption and doing Valsalva maneuver for assurance of pleural disruption. The result of this test was statically significant with statistical value of 44.65 and freedom degree of 1 ($P < 0.0001$).

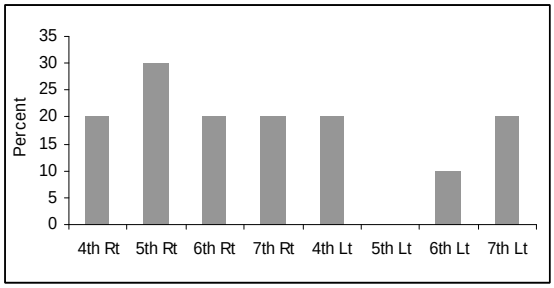

Fig. 3. Probability of pleural disruption after harvesting ribs 4 to 7 on both sides.

DISCUSSION

Rib graft is a kind of autogenous bone used in maxillofacial surgery. In line with temporal fossa and to establish the ram us height. Likewise, it is applied to augment atrophic mandible. Fourth, fifth and sixth ribs are the best choice depending on the required size and shape. The sixth rib is more utilized because one can apply inframammary crease incision to access it. In this method, the least amount of muscle is cut as the incision is in the pectoral is major muscle and rectus abdominis muscle and these muscles are preserved for future muscular flaps (7-9).

Epker *et al.* have shown that the fourth rib is the best rib because it enters directly into the sternum body and is not joined to the upper or the lower ribs at all. Occasionally, the fifth rib is joined to the sixth rib with a chondral matrix before being jointed to the sternum body. This makes the harvesting of the fifth rib difficult but the fifth rib in the growing girls is preferred to the fourth rib because the scar resulted of fourth rib harvesting may interfere with the breast growth (9).

Graft harvesting from the right side is preferred to that of the left side because each side of the rib can be formed in such a way that it is in line with each side of the mandible or the facial bones, but post operative discomfort in the right side is less mistaken for cardiac pain (10).

Nelson *et al*. select the fifth, sixth or the seventh rib of the opposite side for graft because the curve of the opposite rib allows the rib to be in line with the lateral side of ramus, easily (10).

If more ribs are required, 2 adjacent ribs can be harvested. If a large section of bone is needed, intervening rib is kept in a healthy state. In this situation the fifth and seventh ribs are usually used (6). The important point is that the upper ribs, which are larger and wider, are often more suitable for reconstruction of jaw and the rounded head of lower ribs is suitable for joint replacement (11).

But the present study unlike the previous studies that had researched the probability of pleural disruption following CCG was carried out on newly expired adult male cadavers. As the elapsed time is less than 24 hours since the subject's deaths and tissue variations are not observed in pulmonary and pleural tissues during this period, the results of these studies can be compared. In the present study, the probability of pleural disruption was 17.5 percent in total. In the study of Skouteris in 1989, the complications following 31 rib harvestings from 28 patients (9 male and 19 female) were evaluated retrospectively. Thompson *et al.* in 1995 and Whitaker *et al.* in 1976 to 1979 reported the incidence of pneumothorax after rib graft harvesting for maxillofacial surgery in three papers. In two of these reports that included 149 patients in the first and 151 patients in the second, the incidence of pneumothorax was 5.3 percent and 18 percent, respectively. In these two groups of patients, autogenous graft was harvested from calvarium, ribs and iliac crest. The number of individuals under rib graft was not registered. In the third group, the incidence of pneumothorax was registered to be 20 to 30 percent in a group of 793 patients under craniofacial surgery (5, 6).

James and Ivine in 1983 investigated the complications originating from graft harvesting of ribs in a group of 41 patients whose 52 rib grafts were harvested. Rib grafts were used for osteotomies of LeFort I, II and III, reconstruction of TMJ, osteotomy of inverted L and as only grafts for mandible and maxilla. The authors only reported one case of pneumothorax (2 percent) that was related to CCG graft harvesting, but did not explain whether they harvested grafts together with perichondrium and periostei or rot. In the present study, the studied group was limited to male adults but in the previous studies, this group mostly included the growing children. The other difference between this study and the previous ones is that in this study in all cases the length of the bone and cartilage were constant with values of 2.5 and 0.5 cm, respectively, whereas in the previous studies the length of these two variables varied due to surgeon requirements. Also, the superior quantity of the equipment used in the previous studies cannot be ignored coupled with the fact of the previous studies were carried out in an operation room with adequate lighting and where the surgeon is in total control compared with the present study that has been carried out in a dissection room under inferior conditions.

In the present study, a significant difference was not shown to exist access the fourth to seventh ribs of the right and left sides with respect to the probability of pleural disruption, but the fifth rib of the right side that showed pleural disruption in 30 percent of cases, was the highest risk rib and the fifth rib of the left side that did not show pleural disruption at all, was the lowest risk rib. In previous studies, there has been no reference to harvesting of a particular rib. In this study, the site of pleural disruption was infrabony in half of cases and infrachondral in 35 percent of the cases but since the length of chondral section is 1/5 of bony section (0.5 cm against 2.5 cm), The probability of pleural disruption under chondral section is more than the bony section and that in turn requires more attention when disjoining the perichondrium from cartilage in CCG. In the previous studies, the recent finding was not evaluated or referenced.

In our study, the difference between observation by the naked eye and Valsalva maneuver in realizing pleural disruption was significant. This indicates that Valsalva maneuver after CCG is a name credible process than direct observation by the naked eye in distinguishing pleural disruption. In conclusion a specified rib across the fourth to seventh ribs of both sides cannot be counted as the highest risk rib for pleural disruption. Thus, it is better to consider other effective agents and factors during rib harvesting. For example, the right side ribs are preferred to the left side ribs, since their post-operative pains are not mistaken for cardiac pains. If reconstruction and future flaps considered by pectoral is major flap, the sixth and seventh ribs will be recommended for protecting and preserving this muscle, but it is better to pay particular attention and care to chondral section of graft and perichondrium, since adhesion of perichondrium to pleura is stronger than adhesion of perichondrium to skin and therefore, the probability of pleural disruption is more likely under chondral section. Valsalva maneuver has more diagnostic values than observation by the naked eye for evaluation of pleural disruption.

According to the results of this research, it is suggested to consider a rib that owns the least intervention with probable post-operative complications and also its harvesting has no interference with future treatment plans, for CCG graft harvesting in order to reconstruct the bony defects and to provide joint growth. The right sixth rib is an appropriate choice for this purpose. Special attention should be paid for joining perichondrium to pleura during CCG graft, because of high probability of pleural disruption is in this site. Utilizing Valsalva maneuver is preferred to direct observation by the naked eye for detecting probable pleural disruption.

Conflict of interests

We have no conflict of interests.

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