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Pulmonary capacity of patients with total traumatic injury of the brachial plexus submitted to neurotization with the phrenic nerve: a case series.

Capacidade pulmonar de pacientes com lesão traumática total do plexo braquial submetidos à neurotização com o nervo frênico: uma série de casos.

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ABSTRACT

Total traumatic injury often requires surgical intervention such as neurotization using the phrenic nerve with the aim to recover the elbow function. However, its repercussions on the respiratory kinematics are unknown. Objective: To evaluate the ribcage volume in tricompartments division, kinematics of Duty Cycle, and shortening velocity of the respiratory muscles after nerve phrenic transfer. Methods: Five participants (4 male), aged 18 to 40 years old (32±2), diagnosed with total brachial plexus injury and with nerve phrenic transfer. The optoelectronic plethysmography (OEP) was the instrument to evaluate volume in quiet breathing (QB), inspiratory capacity (IC) and vital capacity (VC) of the rib cage in its tricompartments division (pulmonary rib cage, abdominal rib cage and abdomen rib cage) and in each hemithorax, as well as the shortening velocity of the respiratory muscles, and respiratory rate. Assessments occurred 30 days prior and 30 days after surgery. Results: There was a decrease in the total compartmental distribution in QB with statistical difference only in the abdominal compartment ($p < 0.05$). Four patients showed a reduction in the shortening speed of the left diaphragm muscle. It was not possible to perform a group analysis of respiratory kinematics and volumes in CV, IC due to the variation found in each patient analyzed. Conclusion: There was a reduction in volume in the rib cage as well as a change in the speed of shortening of the respiratory muscles after the transfer of the phrenic nerve one month after surgery.

Key words: Plethysmography, Brachial plexus, Phrenic nerve, Nerve phrenic transfer

RESUMO

A lesão traumática total freqüentemente requer intervenção cirúrgica, como neurotização usando o nervo frênico, com o objetivo de recuperar a função do cotovelo. No entanto, suas repercussões na cinemática respiratória são desconhecidas. Objetivo: Avaliar o volume da caixa torácica na divisão dos tricompartimentos, a cinemática do Duty Cycle e a velocidade de encurtamento dos músculos respiratórios após a transferência do nervo frênico. Métodos: Cinco participantes (4 do sexo masculino), com idade entre 18 e 40 anos (32 ± 2), com diagnóstico de lesão total do plexo braquial e transferência do nervo frênico. A pletismografia optoeletrônica (OEP) foi o instrumento para avaliar o volume na respiração silenciosa (QB), a capacidade inspiratória (IC) e a capacidade vital (VC) da caixa torácica em sua divisão tricompartimental (caixa torácica pulmonar, caixa torácica abdominal e caixa torácica do abdômen) e em cada hemitórax, bem como a velocidade de encurtamento dos músculos respiratórios e a frequência respiratória. As avaliações ocorreram 30 dias antes e 30 dias após a cirurgia. Resultados: Houve diminuição da distribuição compartimental total no QB com diferença estatística apenas no compartimento abdominal ($p < 0,05$). Quatro pacientes apresentaram redução da velocidade de encurtamento do músculo diafragma esquerdo. Não foi possível realizar uma análise de grupo da cinemática respiratória e dos volumes em CV, IC devido à variação encontrada em cada paciente analisado. Conclusão: Houve redução do volume da caixa torácica e também alteração da velocidade de encurtamento dos músculos respiratórios após a transferência do nervo frênico um mês após a cirurgia.

Palavras-chave: Pletismografia, Plexo braquial, Nervo frênico, Transferência de nervo frênico

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INTRODUCTION

Among the traumatic plexopathies, total brachial plexus injury presents the worst prognostic due to total denervation of the muscles of the ipsilateral upper arm leading to loss of capacity and performance in activities of daily living.[1]

Two types of donors exist, the extra-plexal nerves such as phrenic nerve, intercostal nerve and accessory, and the intra-plexal nerves including proximal stump of the roots or collateral motor branches of preserved brachial plexus nerves. In TBPI, an option of treatment is the transfer of nerve phrenic (C3-C5) to musculocutaneous nerve (C5-C7)[2,3], this technique has been used since 1970 to restore the function of the biceps brachii muscle in order to improve elbow flexion[1,4].

The main reasons to choose the phrenic nerve as a donor include easy anatomic localization, large number of motor neurons (average 800), and high frequency and amplitude conducting nerve impulses.[8,9] However, the time frame between the injury date and the surgical intervention (should not exceed a year) as well as other cardiorespiratory issues, once this nerve is the main responsible for innervate diaphragm muscle, should be considered.[5,7]

Understanding the importance of the phrenic nerve in respiratory function, we believe that the evaluation of respiratory function before and after nerve transfer surgery with this nerve is relevant[2,3,7]. Although promising, knowledge regarding the repercussions of this surgical technique on the patient's pulmonary volumes and capacity are limited[,6,7]

In this scenario, the use of optoelectronic plethysmography (OEP) as a non-invasive tool capable of accessing each phase of breathing in a three-dimensional way and thereby detecting changes in the volumes of the total rib cage or separated by compartments, as well as in each hemithorax, offers an additional advantage to study the impact of neurotization on the respiratory system. OEP has been used for analysis in several populations, such as post-stroke patients and in different clinical conditions[10], however there is a lack of studies targeting patients who have suffered from TBPI.

Therefore, this study aims to evaluate the distribution of pulmonary volumes and capacities in patients who had total brachial plexus injury and underwent phrenic nerve neurotization.

METHODS

A series of cases were carried out from August 2016 to August 2017 including five patients (4 men), aged between 18 and 40 years (32.6 ± 2.48). Patients were referred from the "Peripheral Nerves Ambulatory of Hospital da Restauração, Recife, PE" with a clinical diagnosis of TBPI confirmed by complementary exams of electroneuromyography (EMG) and Magnetic resonance Imaging (MRI).

Volunteers with TBPI who underwent neurotization with the phrenic nerve were included in this study. Patients had all roots avulsed (four on the left side), using the graft for transferring the phrenic nerve in their surgical procedure. The mean time between trauma and surgery ranged from 5 to 8 months and the phrenic nerve was used completely in the cervical region (Table 1). Exclusion criteria included any chest trauma (rib fracture, pneumothorax, etc.) and/or diagnosis of pre-existing lung disease(s). All assessments were performed at the "Laboratory of Cardiopulmonary Physiotherapy (LACAP)" and at the "Learning and Motor Control Laboratory (LACOM)", in the Department of Physiotherapy at the Federal University of Pernambuco (UFPE). The study was approved by the Ethics and Research Committee with Human Beings at UFPE under the CAEE number: 59986616.9.0000.5208.

Plestismography procedure

Optoelectronic plethysmography (OEP) (ETS) (BTS Bioengenireeirng, Italy) was used to evaluate the total chest cavity volumes, thoracic cavity volume per compartment (pulmonary, thoracic and abdominal) and volumes in both hemithorax and the kinematic variables in the inspiratory capacity, vital capacity and breathing at rest. Eighty-nine reflective, hemispheric markers, 6 mm in diameter, with hypoallergenic tape were fixed on the thorax of the volunteers, 43 on the anterior part, 37 on the posterior part and 10 on the sides of their thorax, from the clavicles to the anterior superior iliac spines, along pre-defined horizontal and vertical lines[11]

For the data acquisition, subjects were in a seated position, with their feet flat on the floor, knees and hips 90º flexion, erect spine, arms supported, elbows flexed at 90º and forearms in neutral position. From this arrangement, subjects were asked to breathe calmly for three minutes, while avoiding speaking or changing posture in order to record the resting volumes fromwhich only the most stable minute was used for evaluation. A further three minutes of vital capacity (VC) maneuver were also recorded and the highest value out of the three was used for analysis.

Images captured by the eight cameras at a frequency of 60 Hz and generated by the infrared light reflections of the 89 markers were then triangulated through the Gaussian theorem, allowing the visualization of the rib cage in its three compartments: pulmonary rib cage (Vrcp) , abdominal thoracic cavity (Vrcab) and abdomen (Vab), as well as in its entirety (i.e. total chest wall, Vtcw). Each compartment was evaluated in terms of volume variation throughout the recorded respiratory cycle, in an absolute way, and divided between the right and left hemithorax. Inspiratory capacity (IC) and vital capacity (VC) were obtained following the same methodology. Variables such as inspiratory time (Tinsp) and total cycle time (Ttot) were calculated to obtain Duty Cycle (Tinsp / Ttot).

From the ratio of Vrca and Vab by inspiratory time, the shortening velocities of the diaphragm and the abdominal muscles were obtained, respectively. To obtain the variable shortening speed the inspiratory muscles (external intercostal muscles, ribcage muscles and diaphragm), the calculation was made based on the ratio between Vrcp variable and inspiratory time[12]. The OEP was performed in the preoperative phase (within the last preoperative month) and in the postoperative phase, respecting the period between 15 and 30 days after the procedure, which was established by the coincidence according to the postoperative reassessment by the surgical team.

Statistical Analysis

The data were tabulated using Microsoft Excel 2016 software and then analyzed using SPSS Statistics® software version 22.0. For the descriptive analysis for the five study participants, the absolute values of each dependent variable were used, as well as their percentage variation calculated using the formula (Post-surgical volume - Pre-surgical volume / Pre-surgery volume x 100). The data are expressed in absolute values and the volumes of the rib cage both in quiet breathing and IC and VC are also expressed as a percentage of contribution to the Vtcw. Wilcoxon's non-parametric test was used to analyze the comparison between the pre- and post-operative periods of lung volumes in total lung box, as well as separately between the right and left hemibodies. A 95% confidence level and a p-value <0.05 were used for all tests.

RESULTS

Table 1 shows the characterization of the studied sample. No patient had postoperative complications during the evaluation period. Regarding the compartmental distribution in the pulmonary rib cage, although there was a reduction in lung volumes after surgery, only the decrease in Vab was statistically significant (Before: 423.00 ± 314.73 ml; After: 187.00 ± 148.68 ml, p-value <0, 05) (Figure 1). Additionally, it was observed that this decrease in volume of the abdominal compartment occurred both on the right side (Before: 114.89 ± 95.33 ml; After 76.01 ± 84.43 ml, p-value <0.05) and on the left side (Before: 124.70 ± 103.91 ml; After : 82.62 ± 88.80 ml, p-value <0.05) (Figure 2).

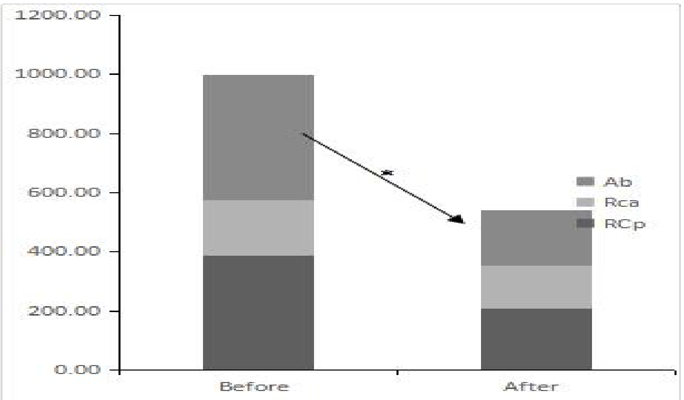

Figure 1. Quiet Breathing (QB) compartmental distribution in the three pulmonary compartments before and after the surgical procedure. * p-value <0.05

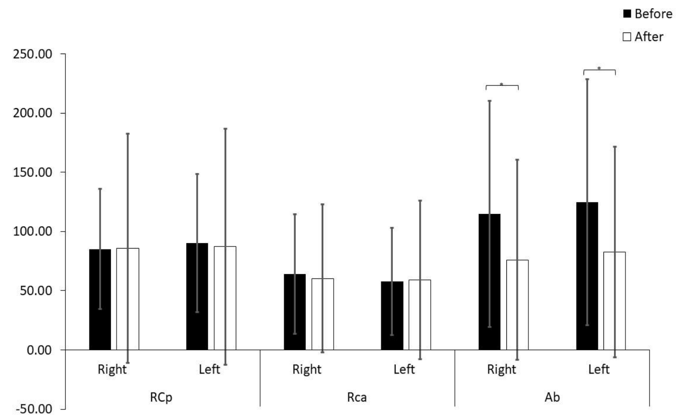

Figure 2. Compartmental distribution of volumes in Quiet Breathing (QB) on the right and left sides before and after the surgical procedure

Checking the behavior of the respiratory musculature in relation to its shortening speed, it was observed that the left diaphragm muscle decreased its shortening speed in three patients with left plexus injury (patients 3, 4 and 5) and one with right plexus injury (patient 2). There was a reduction in the speed of shortening of the abdominal muscles in patients 1, 3, 4 and 5, all with lesions of the left plexus (Figure 4).

Analysis of the respiratory kinematics and volumes in vital capacity (VC) and inspiratory capacity (IC) was not possible due to individual variability within the sample (Table 3).

DISCUSSION

The aim of the present study was to evaluate the distribution of lung volumes and capacity in patients with total brachial plexus injury submitted to neurotization with the phrenic nerve. In view of the results presented, it was observed that the abdominal compartment decreased in volume and the diaphragm muscle decreased its shortening speed in the postoperative period.

Therefore, we may suggest that after neurotization, patients decrease the speed of contraction of the diaphragm causing a compensatory shortening of the abdominal muscles and, consequently, decreasing the volume distribution in this compartment. This fact can be explained by the necessary antagonist nature between the diaphragm and the abdominal muscles, which allows the chest wall to expand while keeping the larger volume in the abdominal rib cage[13].

Patient 1 had thoracoabdominal asynchrony, that is, during inspiration there was a gain in volume in the right pulmonary rib cage and a reduction in right abdominal volume. On exhalation, the volume of the right pulmonary rib cage decreases and the right abdominal volume increases. Such asynchrony may be related to a significant decrease in the speed of shortening of the abdominal muscles, which leads to an increase in the speed of shortening of the inspiratory muscles, as seen in Figures 3 and 4.

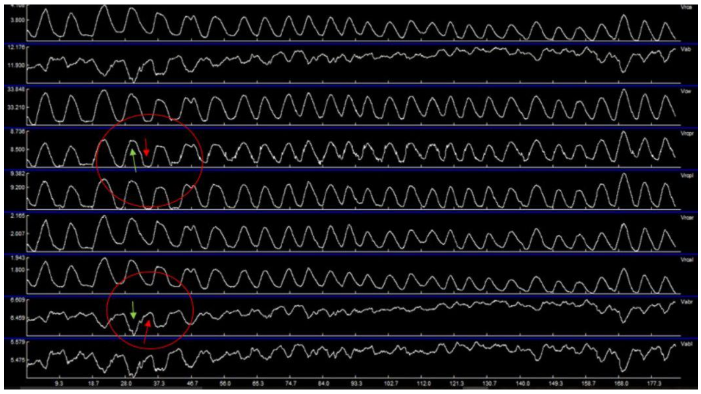

Figure 3. Thoracoabdominal asynchrony in patient 1 during quiet breathing. It is noted that during an inspiration, represented by green arrows, there is a volume gain of the right lung chest and a reduction of right abdominal volume. This same asynchrony is seen during expiration (red arrows).

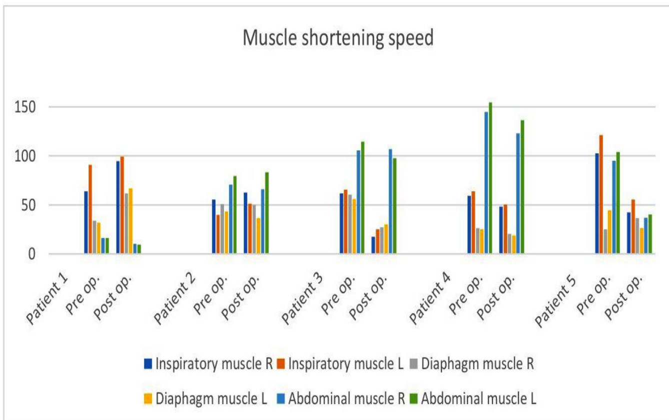

Figure 4. Shortening rate of respiratory muscles (seconds) Pre op.: preoperative; Post op: post-operative; Inspiratory M R: Right Inspiratory Muscles; Inspiratory M L: Left Inspiratory Muscles; Diaphragm M R: Right Diaphragm Muscle; Diaphragm M L: Left Diaphragm Muscle; Abdominal M R: Right Abdominal Muscles; Abdominal M L: Left Abdominal Muscles

When the side of the lesion is analyzed, the patient with a total brachial plexus lesion on the right and neurotization of the phrenic nerve on the right may demonstrate greater respiratory repercussions. These repercussions were demonstrated by the patient in the respiratory rate (RR), which was approximately 12 bpm before and 17 bpm after the procedure. This can be interpreted as a compensation to maintain ventilation considering the RR is increased to guarantee greater uptake of O_2 (Table 2)[14]. In addition to this change, the patient presented a reduction in volume in all compartments and obtained an increase in the shortening speed of the inspiratory muscles; in other words, with the reduction of the total lung volume, an increase the RR is observed consequently using more inspiratory muscles to guarantee ventilation. Thus, it is likely that the fact that the right hemicupula of the diaphragm rests on the upper hepatic surface forming a physiological mechanical barrier, makes this hemithorax the most impaired in phrenic nerve transfers[15].

A study with 165 patients with brachial plexus injury who underwent nerve transfer surgery used radiographs to determine a diaphragmatic height index. In this study it was found that the right side of the hemicupula is higher than the left side. Additionally, a non-significant difference in the height of the diaphragmatic hemicupula in patients who underwent phrenic nerve surgery was found when compared to the control group[14].

When we analyze the results presented by Pornrattanamaneewong and colleagues regarding the difference in diaphragmatic height with the results presented by our study with OEP, we can infer that there is a visible anatomical difference by radiography in patients after phrenic nerve surgery, as well as a change in the distribution of volumes by compartment as detected by OEP. Radiography is a simple, low-cost method that uses ionizing radiation to capture images, to obtain anatomical differences in these patients; however, it is subjective to the evaluator's interpretation and the patient's position at the time of capture. On the other hand, despite OEP's high cost, this method is a more sensitive tool to detect minimal changes in volume within the three-compartments in the lung, which allows us to infer possible repercussions and compensations acquired by patients after injury.

There was a loss in volume values in total vital capacity in patients 2 (13%), 3 (5%) and 5 (21%), while patients 1 and 4 were able to compensate with other compartments and even increased their total vital capacity (32 % of patient increase 1 and 9% patient 4).This was probably due to the fact that even though all patients present a loss in abdominal volume varying between 5% and 202%, patients 1 and 4 were able to compensate more effectively from other compartments thus, adding volume to the total vital capacity.

The inspiratory capacity analysis showed that patients 1,2,3 and 5 had a loss of volume in the inspiratory capacity in all compartments with patient 2 obtaining a 2% increase in the postoperative period. Inspiration requires the diaphragm to be lowered and the accessory muscles of inspiration to increase the diameter of the rib cage thus, obtaining the inspiratory capacity. If any of these muscles are altered, muscular compensation occurs and a consequent change in the volume in the inspiratory capacity is observed. Thus, patients who had a loss of volume in total inspiratory capacity, obtained a gain in inspiratory capacity in the thoracic compartment where the accessory muscles of inspiration were activated.

Although the phrenic nerve has long been used as a donor nerve to restore muscle function after brachial plexus injury, little is known about the possible change in lung function in the long term. Most studies suggest that phrenic nerve surgery does not result in long-term consequences for lung function[4,5,10,14]; however, another study shows that regardless of the surgical technique used for phrenic nerve neurotization, patients will show a decrease in the pulmonary function test from the first post-surgical week which will be gradually recovered starting at the third post-surgical month[16].

Thus, by using a more sensitive tool with optoelectronic plestimography, our study obtained important differences in lung volumes even after 30 days post-operative. Although no clinical repercussions were observed, this study showed that patients submitted to phrenic nerve neurotization showed changes in respiratory muscle mechanics as well as in the volume distribution in the compartments. We suggest that future studies be carried out including a larger number of patients and long-term evaluation while also incorporating pulmonary function tests to verify possible clinical repercussions.

Limitations associated to this study include the small and heterogeneous sample number and the short time for follow-up.

Therefore future studies should include a longer follow-up and a larger sample, so that respiratory physiotherapy can be performed early and preventively in this population so that there are no possible long-term clinical repercussions.

CONCLUSION

In the assessments of respiratory capacity after about 30 days after the surgical procedure, it was possible to observe possible changes in the volumes of the rib cage in individuals with total brachial plexus injury submitted to neurotization with the phrenic nerve. A decrease in the total abdominal volume and on the left side, in addition to changes in the diaphragmatic shortening speed on the left side were observed. In some patients, it was possible to observe greater repercussions in terms of volume and changes in respiratory kinematics.

This study proved to be a pioneer by using OEP which is considered a more reliable instrument to evaluate the variation of the three-compartment volume of the rib cage when compared to other methods.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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Table 1. Sample characterization of five patients submitted to phrenic nerve neurotization after traumatic total brachial plexus injury.

Patients	Age (Years)	Injury side	Type of accident	Date of injury	Date of surgery
1	31	Left	Motorcycle	May/2016	October/2016
2	33	Right	Motorcycle	June/2016	November/2016
3	36	Left	Motorcycle	Augst/2016	January/2017
4	28	Left	Car	September/2015	May/2016
5	35	Left	Motorcycle	June/2016	February/2017

Table 2 - Data on ventilatory kinematics, tricompartmental distribution of thoracic cavity volumes and rates of contraction of respiratory muscles in each hemithorax on the pre- and post-operative period.

Voluntary	**RR (min)**	***DUTY CYCLE***	**Vtcw (mL)**	**V_{RCP} (mL)**	**V_{RCA} (mL)**	**V_{AB} (mL)**	**Speed of inspiratory Muscles R(s)**	**Speed of inspiratory Muscles L(s)**	**Speed of the diaphragm R(s)**	**Speed of the diaphragm L(s)**	**Abdominal speed R (s)**	**Abdominal speed L (s)**
Voluntary 1												
Pre	17.23	0.45	423	259	110	54	63.92	90.80	34.05	31.66	16.13	16.13
Post	10.284	0.44	784	502	333	-52	94.52	99.15	61.73	66.74	10.42	9.65
Voluntary 2												
Pre	12.71	0.44	755	235	202	317	55.582	40.04	50.87	43.33	70.66	79.60
Post	17.476	0.46	528	173	129	226	62.38	51.04	49.78	36.55	66.16	83.18
Voluntary 3												
Pre	11.25	0.37	929	256	233	440	61.94	65.44	60.44	55.94	105.40	114.39
Post	16.26	0.36	415	58	78	279	17.58	24.91	27.11	30.04	106.96	97.44
Voluntary 4												
Pre	17.65	0.35	609	158	66	384	59.24	63.91	26.50	24.94	144.97	154.33
Post	16.40	0.33	504	125	51	329	48.07	50.43	20.49	18.91	122.93	136.33
Voluntary 5												
Pre	7.917	0.54	2278	1036	322	920	102.63	121.22	25.28	44.30	95.07	103.72
Post	14.62	0.47	472	194	125	153	42.45	55.58	36.38	26.28	36.89	40.43

Table 3 - Three-part distribution of thoracic cage volumes (ml) of each hemithorax on the pre- and post-operative period

Voluntary	V_{RCP} Right	V_{RCP} Left	V_{RCA} Right	V_{RCA} Left	V_{AB} Right	V_{AB} Left	Vtcw
Voluntary 1							
VC (Pre)	613 (33%)	694 (38%)	195 (10%)	229 (12%)	40 (2%)	65 (3%)	1837
VC (Post)	530 (21%)	551 (22%)	725 (29%)	740 (30%)	-41 (-1.8%)	-66 (-2.7%)	2439
Gain and/or Loss - VC (%)	-14	-21	272	223	-202	-202	32
IC (Pre)	450 (29%)	714 (47%)	126 (8.3%)	186 (12.6%)	21 (1.4%)	20 (1.3%)	1517
IC (Post)	413 (27%)	510 (34%)	509 (34%)	585 (39%)	-291 (-19.5%)	-240 (-16%)	1486
Gain and/or Loss - IC (%)	-8	-29	204	115	-1382	-1300	-2
QB (Pre)	107 (25%)	152 (36%)	57 (13%)	53 (12%)	27 (6%)	27 (6%)	423
QB (Post)	245 (31%)	257 (33%)	160 (20%)	173 (22%)	-27 (-3.4%)	-25 (-3.1%)	783
Gain and/or Loss - QB (%)	129	69	181	226	-300	-296	85
Voluntary 2							
VC (Pre)	499 (15%)	397 (12%)	536 (16%)	371 (11%)	755 (22%)	772 (23%)	3330
VC (Post)	416(14%)	296 (10%)	506 (17.5%)	356 (12%)	672 (23%)	638 (22%)	2884
Gain and/or Loss - VC (%)	-17	-25	-6	-4	-11	-17	-13
IC (Pre)	358 (15.4%)	381 (16.4%)	315 (13.6%)	312 (13.5%)	430 (18.6%)	515 (22%)	2311
IC (Post)	345 (17.5%)	297 (15%)	385 (19.5%)	310 (16%)	323 (16.4%)	309 (15.6%)	1969
Gain and/or Loss - IC (%)	-4	-22	22	-0,06	-25	-40	-14
QB (Pre)	118 (16%)	85 (12%)	108 (15%)	92 (13%)	150 (21%)	169 (23%)	722
QB (Post)	99 (18%)	81 (14.6%)	79 (14%)	58 (10%)	105 (19%)	132 (24%)	554
Gain and/or Loss - QB (%)	-16	-5	-27	-37	-30	-22	-23
Voluntary 3							
VC (Pre)	211 (10%)	179 (8%)	220 (10.6%)	195 (9%)	624 (30%)	631 (30.6%)	2060
VC (Post)	177 (9%)	192 (10%)	214 (11%)	180 (9.2%)	594 (30%)9	598 (30.5%)	1955
Gain and/or Loss - VC (%)	-16	7	-27	-8	-5	-5	-5
IC (Pre)	237 (14%)	219 (12%)	223 (13%)	189 (11%)	409 (24%)	441 (26%)	1718
IC (Post)	154 (10%)	184 (12%)	190 (12.6%)	141 (9%)	412 (27%)	425 (28%)	1506
Gain and/or Loss - IC (%)	-35	-16	-15	-25	0,7	-4	-12
QB (Pre)	124 (13%)	131 (14%)	121 (13%)	112 (12%)	211 (23%)	229 (24.5%)	928
QB (Post)	24 (5%)	34 (8%)	37 (9%)	41(10%)	146 (35.5%)	133 (32%)	412
Gain and/or Loss - QB (%)	-81	-74	-69	-63	-31	-42	-55
Voluntary 4							
VC (Pre)	724 (21%)	764 (22%)	351 (10%)	377 (11%)	582 (17%)	625 (18%)	3423
VC (Post)	779 (21%)	856 (23%)	459 (12%)	479 (13%)	514 (14%)	646 (17%)	3733
Gain and/or Loss - VC (%)	8	12	31	27	-11	3	9
IC (Pre)	552 (28%)	503 (26%)	258 (13%)	229 (12%)	179 (9%)	205 (10%)	1926
IC (Post)	662 (33%)	488 (24%)	359 (18%)	279 (14%)	70 (3%)	115 (5%)	1973
Gain and/or Loss - IC (%)	20	-3	40	22	-61	-44	2
QB (Pre)	76 (12%)	82 (13%)	34 (5%)	32 (5%)	186 (30.5%)	198 (32.5%)	608
QB (Post)	61 (12%)	64 (12,6%)	26 (5%)	24 (4%)	156 (31%)	173 (34%)	504
Gain and/or Loss - QB (%)	-20	-22	-24	-25	-16	-13	-17
Voluntary 5							
VC (Pre)	1027 (23%)	873 (19%)	313 (7%)	347 (8%)	1014 (22%)	857 (19%)	4431
VC (Post)	831 (24%)	919 (26%)	391 (11%)	396 (11.4%)	429 (12%)	505 (14.5%)	3471
Gain and/or Loss - VC (%)	-19	0.052692	25	14	-58	-41	-21
IC (Pre)	65 (24.5%)	630 (23%)	252 (9%)	220 (8%)	460 (17%)	437 (16%)	2650
IC (Post)	520 (26%)	597 (29.5%)	271 (13%)	258 (12.8%)	136 (6%)	226 (11%)	2008
Gain and/or Loss - IC (%)	-20	-5	7	17	71	48	-24
QB (Pre)	475 (21%)	561 (24.6%)	117 (5%)	205 (9%)	440 (19%)	480 (21%)	2278
QB (Post)	84 (18%)	110 (23%)	72 (15%)	52 (11%)	73 (15%)	80 (17%)	471
Gain and/or Loss - QB (%)	-82	-80	-38	-75	-84	-83	-79