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Predictive Factors in the Outcome of Surgical Repair of Abdominal Rectus Diastasis

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Background: The aim of this study was to define the indicators predicting improved abdominal wall function after surgical repair of abdominal rectus diastasis (ARD). Preoperative subjective assessment quantified by the validated Ventral Hernia Pain Questionnaire (VHPQ) was related to relative postoperative functional improvement in abdominal muscle strength.
Methods: Fifty-seven patients undergoing surgery for ARD completed the VHPQ before surgery. Preoperative pain assessment results were compared with the relative improvement in muscle strength measured with the BioDex system 4.
Results: There was a correlation between the relative improvement in muscle strength measured by the BioDex System 4 for flexion at 30 degrees ($P = 0.046$) and 60 degrees per second ($P = 0.004$) and the preoperative question, "Do you find it painful to sit for more than 30 minutes?" There was also a correlation between BioDex improvement for flexion at 30 degrees ($P = 0.022$) and for isometric work load ($P = 0.038$) and the preoperative question, "Has abdominal pain limited your ability to perform sports activities?" The VHPQ responses also formed a pattern with a fairly good correlation between other BioDex modalities (with the exception of extension at 60 degrees per second) and the response to the question regarding complaints when performing sports. Postoperative visual analog scale ratings of abdominal wall stability correlated to the questions regarding complaints when sitting ($P = 0.040$) and standing ($P = 0.047$). No other correlation was seen.
Conclusion: VHPQ ratings concerning pain while being seated for more than 30 minutes and pain limiting the ability to perform sports are promising indicators in the identification of patients likely to benefit from surgical correction of their ARD. *(Plast Reconstr Surg Glob Open 2016;4:e702; doi: 10.1097/GOX.0000000000000688; Published online 5 May 2016.)*

The clinical significance of abdominal rectus diastasis (ARD) is debatable. Even though there are several studies indicating that weak abdominal integrity because of ARD causes symptoms of pain and weakness of the abdominal wall and a decreased quality of life,[1,2] there are still authors who claim that ARD is just an aesthetic issue.[3] Conclusive studies on the relationship between subjective symptoms and the width of ARD are lacking. On the contrary, core physiology measured with the BioDex system 4 (BioDex Corp., Shirley, N.Y.) is correlated to the width of ARD below the umbilicus[4] as measured during surgery. Currently, there are no simple objective measurements in the preoperative period that correlate to patient complaints or predict outcome of surgery. It is of obvious importance to de-

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velop objective tools that indicate which patients will benefit from surgery, from both the subjective perspective and objective improvement in abdominal wall strength.

Until the past decade, recurrence has been the main and often only outcome measurement of abdominal wall reconstructive surgery. Decreasing recurrence rates using modern methods for reconstruction and reinforcement have required a shift of focus to more patient-oriented outcome measurements. Such important outcomes are long-term pain and abdominal wall function. Although several instruments exist for evaluation of pain, few studies have been done examining the relationship between perceived pain, patient-rated limitations in daily life, and objective evaluation of abdominal wall strength. One obvious reason is that until recently, no validated methods for evaluation of abdominal muscle strength have been available.[5]

The aim of this study was to explore the relevance of subjective complaints quantified with the validated Ventral Hernia Pain Questionnaire (VHPQ)[6] and their relation to postoperative functional improvement in abdominal muscle strength. This might help to decide whether surgery will help the patients' problem in case of ARD.

MATERIALS AND METHODS

Patients

Patients included in the study had an ARD greater than 3 cm. The normal width of the linea alba is less than 22 mm above and less than 16 mm below the umbilicus.[7] The patients were part of a randomized controlled trial comparing plication with mesh reinforcement for correction of ARD.[1] ARD was measured both below and above the umbilicus between the xiphoid process and umbilicus and between the umbilicus and pubic symphysis. Inclusion in this study was made regardless of surgical treatment determined by randomization in the original study. There were 57 patients: 55 women and 2 men. Median age of the patients was 42.8 years (range, 26.9–66.9 years), and median body mass index was 23 kg/m^2 (range, 18–31 kg/m^2). One patient did not complete the 1-year postoperative BioDex measurement, and in 1 case, data were not interpretable because of a technical failure. These patients were excluded from further analysis.

Written informed consent was completed before randomization. The study was approved by the Regional Ethics Board (D.nr. 2009/227–31) and registered at ClinicalTrials.gov with the number 2009/227–31/3/PE/96. Clinical follow-up was performed after 3 and 12 months. Patients completed a VHPQ and had BioDex measurements taken before surgery and at 12 months after surgery.

VHPQ

VHPQ is a questionnaire validated for pain after ventral hernia repair.[6] This questionnaire was developed from the widely used Inguinal Pain Questionnaire.[8] These questionnaires quantify the impact on daily life related to complaints from the abdominal wall or inguinal area. Because some pain may exist before surgery, the questionnaire was answered before surgery and twelve months postoperatively for comparison. Questions asked - does abdominal pain make it difficult to: rise from a low chair; sit; stand; climb the stairs; drive a car; or perform sports? There is also a question regarding the use of analgesics during the previous week due to pain from the abdominal wall and one regarding stiffness and rigidity of the abdominal wall. The severity of pain is graded from 0 = no pain to 6 = pain so severe that the patient is forced to seek medical attention.

BioDex System 4

The BioDex Multi-Joint System-4 (BioDex Corp.) was used for the measurement of abdominal muscle strength. This device has been developed to test and train a specific muscle or group of muscles. With the intention to create a tool for the evaluation of long-term effects on abdominal muscle strength after surgical repair of large ventral hernias, our group developed a model using a unit designed for the back. This model was first validated for giant ventral hernia[9] and thereafter for ARD[10] and was used for all recordings.

When seated in the Biodex apparatus, adjustments can be made for the angle of the back, hip, thigh, and legs to achieve optimal comfort. These settings are recorded for later use to ensure consistency in testing parameters. Maximal movement was 20 degrees extension and 10 degrees flexion. In the test situation, flexion at 30 degrees and 60 degrees per second, extension at 30 degrees and 60 degrees per second, and isometric force tests were performed. All 5 tests consist of 5 repetitions and are repeated twice after 5 minutes of rest. The average maximal performance, peak torque from each repetition, was used for calculation, and results are measured in Newton meter. Both maximal strength and maximal work are quantified. Test subjects sit in a chair-like position with straps around their legs and chest. Positioning during the test situation was stored for exact reproducibility. Tests were performed before and 12 months after surgery.

VAS

The patients reported abdominal muscle strength improvement 12 months after surgery using a numerical visual analog scale (VAS), where 0 = no improvement and 10 = improvement more than I believed I could.[11,12]

Statistics

STATISTICA version 12 (Statsoft, Tulsa, Okla.) was used for all calculations. The Kendall Tau test was used to analyze the relationship between preoperative VHPQ ratings and relative improvement in muscle strength measured by BioDex, including flexion and extension at 30 and 60 degrees and isometric force. This test was also used to correlate improvement in VAS with preoperative VHPQ ratings. Spearman rank order was used to correlate VAS with relative improvement in muscle strength measured by the BioDex.

RESULTS

Values for abdominal muscle strength recorded by the BioDex system are given in Table 1. This table also shows the relative change in strength when comparing preoperative and postoperative measurements. Relative change was chosen as the outcome variable because there was considerable interindividual variability in preoperative muscle strength. As shown, a few patients had decreased muscle strength postoperatively. One patient showed a decrease in muscle strength by almost 50% in all categories, and this patient accounts for all the negative recordings in the "minimum %" column for change in Table 1.

There was a correlation between the relative improvement in muscle strength as measured by the BioDex for flexion at 30 degrees (p = 0.046) and 60 degrees per second ($P = 0.004$) and score for the question "Does pain make it difficult to sit for more than 30 minutes?" There was also a correlation between BioDex improvement for flexion at 30 degrees ($P = 0.022$) and for isometric work load ($P = 0.038$) and the preoperative question "Has abdominal pain limited your ability to perform sports activities?" (Table 2). Furthermore, a fairly good correlation was shown between the other BioDex modalities (with exception for extension at 60 degrees per second) and the response to the question about complaints when performing sports. Postoperative VAS ratings of abdominal wall stability correlated to the questions regarding complaints when sitting ($P = 0.040$) and standing ($P = 0.047$; Table 3).

No other correlations were present between the outcome of surgical correction of ARD, defined as relative improvement in muscle strength measured with BioDex, and preoperative scoring in the VHPQ questionnaire. There was no correlation between subjective postoperative improvement of abdominal wall stability measured on a VAS and BioDex improvement for extension, flexion, or isometric measurements.

DISCUSSION

Key question scores in the VHPQ could possibly indicate those patients likely to benefit from surgery and thereby be an aid when deciding who should be offered surgery for ARD. From our results, it would seem that VHPQ ratings for being seated for more than 30 minutes or the ability to perform sports may be of importance in identifying patients likely to benefit from surgical correction of their ARD. Considering girdle weakness in persons with ARD, it seems logical that these specific complaints may reflect the potential to improve abdominal muscle strength by corrective surgery. Abdominal wall stability was deemed poor in this group of patients and was confirmed by lower BioDex values before surgery. Abdominal muscle strength is important for prolonged sitting and sports activity.

When interpreting analyses listed in Table 2, there is a tendency toward a pattern indicating a relationship between complaints when being seated and flexion, regardless of speed, as well as between complaints when performing sports and all BioDex modalities with exception of extension at 60 degrees per second. Although strict statistical significance was not reached for all relationships, the results are not randomly distributed between the questions and outcome of BioDex exercises. The number of analy-

Table 1. BioDex Performance

BioDex Modality	Median (Nm)	Minimum (Nm)	Maximum (Nm)	Quartile Range (Nm)	Median Change (%)	Minimum (%)	Maximum (%)
Flexion 30 degrees	83.8	29.6	227	45.5	14	–46	273
Flexion 60 degrees	95.1	34	233	37.7	14	–33	287
Extension 30 degrees	100	39.6	239	39.6	15	–54	216
Extension 60 degrees	102	36.9	255	44.3	17	–57	244
Isometric	63.1	14.6	143	30.1	24	–40	526

BioDex performances in median (Newton meter) with minimum/maximum recordings and interquartile range for the different modalities. Relative change (%) between the preoperative and postoperative measurements with range (minimum and maximum).

Table 2. Correlation between Delta BioDex and the Various VHPQ Parameters

BioDex Modality and VHPQ Question	n	Kendall Tau	Z	*P*
ΔFlexion 30 degrees				
Last week (1)	54	0.059	0.63	0.53
Rise (2)	52	0.11	1.1	0.27
Sit (3)	53	0.19	1.99	0.046
Stand (4)	52	0.02	0.21	0.83
Stairs (5)	54	–0.0028	–0.029	0.98
Drive (6)	53	0.0095	0.1	0.92
Perform sports (7)	52	0.22	2.28	0.022
ΔFlexion 60 degrees				
Last week (1)	54	0.043	0.46	0.64
Rise (2)	52	0.081	0.85	0.4
Sit (3)	53	0.29	2.85	0.0044
Stand (4)	52	0.0015	0.016	0.99
Stairs (5)	54	0.0028	0.029	0.98
Drive (6)	53	0.09	0.95	0.34
Perform sports (7)	52	0.18	1.88	0.06
ΔExtension 30 degrees				
Last week (1)	54	0.059	0.63	0.53
Rise (2)	52	0.017	0.18	0.86
Sit (3)	53	0.038	0.41	0.68
Stand (4)	52	–0.0046	–0.049	0.96
Stairs (5)	54	–0.0055	–0.059	0.95
Drive (6)	53	–0.090	–0.95	0.34
Perform sports (7)	52	0.15	1.57	0.12
ΔExtension 60 degrees				
Last week (1)	54	–0.079	–0.84	0.4
Rise (2)	51	–0.089	–0.92	0.36
Sit (3)	53	–0.035	–0.37	0.71
Stand (4)	52	–0.088	–0.92	0.36
Stairs (5)	54	–0.077	–0.82	0.41
Drive (6)	53	–0.095	–0.99	0.33
Perform sports (7)	52	0.057	0.6	0.55
ΔIsometric				
Last week (1)	55	0.058	0.63	0.53
Rise (2)	53	0.1	1.1	0.27
Sit (3)	52	0.01	1.04	0.71
Stand (4)	51	0.041	0.43	0.67
Stairs (5)	53	–0.028	–0.30	0.76
Drive (6)	52	–0.018	–0.19	0.85
Perform sports (7)	51	0.2	2.07	0.038

Delta BioDex was calculated as a relative change according to the preoperative value. Questions from the VHPQ were as follows: (1) Have you experienced pain last week? Do you have pain: (2) when rising from a low chair? (3) when sitting for more than 30 minutes? (4) when standing for more than 30 minutes? (5) when climbing the stairs? (6) when driving your car? (7) when performing sports? Patients not performing an activity were excluded from that specific analysis. Calculations are made with Kendall Tau. n = number of patients.

Table 3. Correlation between Preoperative VHPQ and VAS Assessment of Subjective Improvement of Abdominal Wall Strength after Surgery

Improvement (VAS) and VHPQ Question	n	Kendall Tau	Z	*P*
Last week (1)	55	–0.006	–0.063	0.95
Rise (2)	53	0.013	1.4	0.16
Sit (3)	54	0.19	2.05	0.04
Stand (4)	53	0.19	1.98	0.047
Stairs (5)	55	0.085	0.91	0.36
Drive (6)	54	0.073	0.78	0.44
Perform sports (7)	53	0.051	0.54	0.59

Questions from the VHPQ were as follows: (1) Have you experienced pain last week? Do you have pain: (2) when rising from a low chair? (3) when sitting for more than 30 minutes? (4) when standing for more than 30 minutes? (5) when climbing the stairs? (6) when driving the car? (7) when performing sports? Calculations are made with Kendall Tau. Number of patients = 55.

ses made may increase the risk for results appearing by chance, but because there is both a logical explanation to the results and a systematic pattern, this seems less likely.

ARD is common after pregnancy or extensive weight loss. Most authors claim that surgery for ARD is purely cosmetic because there is no hernia and thereby no risk for strangulation.[3,13] Improvement in the Short Form (36) Health Survey and VAS after surgery suggest that repair of ARD is not entirely cosmetic.[14] However, women with ARD complain of a weak abdominal girdle, discomfort in the abdominal wall, and pain. Among patients with pelvic floor dysfunction (PFD), approximately 50% have an ARD.[2] This may indicate a general weakness of collagen structures ultimately leading to both ARD and PFD. Another possibility is that ARD is the primary disease, and a weak abdominal wall leads to further complaints from PFD.

The establishment of a reproducible relationship between specific preoperative symptoms and improvement in abdominal muscle strength after surgical correction of ARD will facilitate selection of patients, who, with a certain degree of probability, may benefit from surgery. Brauman[15] suggests that the degree of protrusion of the linea alba, which may be related to muscle strength, is of greater importance than the width of ARD as a basis for the decision to operate, which may be congruent with the magnitude of muscular improvement. Improvement in abdominal muscle strength may be all that is necessary to alleviate pain and be able to perform sports and sit for a longer period of time.

Equally important as identifying patients suited for ARD repair is to sort out those who are not suitable candidates for surgery. Further studies are needed to elicit the factors predictive for negative outcome to avoid the risk for long-term pain and impaired quality of life.

In 1997, Nahas et al[16] stated in their article that it is possible to correct ARD. However, we still lack criteria that can be used to select those who are likely to benefit from surgical correction. In many cases, abdominal muscle training may be as good as surgery and does not carry the risk of surgical complications.[14,17]

One weakness of this study is the use of the VHPQ for patient assessment because this instrument is validated for measuring postoperative pain after surgi-

cal correction and not pain existing before surgery. Despite this, the VHPQ has been used as a preoperative questionnaire,[18] and the results indicate that it is proper to use it even in this situation. To be able to evaluate postoperative pain, the degree of preoperative pain must be known. Furthermore, there may be a difference between complaints from a hernia and complaints from an ARD. When evaluating short-term[1] and long-term[14] outcome of the initial randomized study, it was, however, shown that the VHPQ detected a considerable number of patients complaining from their ARD when performing different activities. These complaints decreased with time after surgical repair and were clearly reduced at 3 months[1] and further decreased at 1 year follow-up.[14] With the exception of complaints when driving a car, restrictions after surgery were reduced in response to all activity-related questions.

There is still a possibility that the VHPQ is not sensitive enough to detect all relevant complaints from ARD. It may be that the scale of complaints is more calibrated for larger ventral hernia although the lower limit for defects included in the validation study[6] was a diameter of 3 cm. It may also be the case that the number of patients necessary to definitely define grid parameters is larger than the number of patients included in this study designed for detection of recurrence of ARD. However, knowledge regarding which activities are most critical to predict outcome is a requisite for future development of a dedicated questionnaire for preoperative evaluation of complaints from ARD. From this perspective, the present data are a step forward, because no studies on predictive parameters exist today.

Two different methods for surgical correction of ARD were used in this study, with the initial aim of comparing complications and recurrence. Because there were no statistical differences between the 2 methods with regard to demographic data or improvement of abdominal muscle force, all patients are analyzed as 1 group in this study. Furthermore, in a previous study determining the relationship between the width of ARD and BioDex performance,[4] body mass index and abdominal circumference were not correlated with abdominal muscle strength. Therefore, no correction for these parameters was made in the present analyses. There was a considerable variation in abdominal muscle strength between patients (Table 1), and, as a consequence, analyses were based on the relative change comparing the preoperative and postoperative recordings.

We now have 2 potentially valid preoperative criteria for deciding on the treatment of ARD. One is the degree of ARD protrusion[15] and the other the VHPQ questions regarding pain when sitting for a long time and when performing sports. These possibilities require further investigation if they are to form an evidence base for decision making, even if other signs and symptoms may also be required.

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