ABSTRACT

Background: Changes in paraspinal muscle cross-sectional surface area (CSA) have been shown to occur in patients with chronic and acute low back pain. Numerous factors can affect muscle density; however, the relationship between metabolic disease, such as type II diabetes mellitus (DM) and lumbar paraspinal morphometry, has not been examined. Therefore, we set out to compare paraspinal CSA in diabetic patients undergoing lumbar fusion to patients without diabetes.

Methods: A retrospective review of 101 patients, who underwent posterior lumbar fusion for degenerative spondylolisthesis, was performed. Data collected included preoperative Oswestry Disability Index, SF-12 physical and mental health scores, and visual analog scale for back pain. Utilizing standard measurement software for the iliocostalis, longissimus, multifidus, and psoas muscles, individual paraspinal muscle CSA was measured on preoperative magnetic resonance imaging. Average CSA measurements were then compared between diabetic and non-diabetic patients utilizing Student's t-test.

Results: Thirteen patients were included in the DM group while 88 composed the non-DM group. There were no differences in age or body mass index between the groups. There were no significant differences in preoperative health-related outcome scores. Average psoas muscle iliocostalis as well as multifidus CSA were not significantly different between the non-DM and DM groups (p=0.09, 0.263, 0.458). The longissimus CSA was significantly decreased in the DM group compared to the non-DM (p=0.004).

Conclusions: This study shows that type II DM is associated with decreased paraspinal muscle CSA, but this finding was specific to the longissimus muscle. Our findings suggest that metabolic factors may play an important role in the maintenance of paraspinal muscle balance.

Level of Evidence: Level IV, cohort study

Key Words: lumbar spine, paraspinal musculature, diabetes mellitus, sarcopenia, magnetic resonance imaging

INTRODUCTION

Type II diabetes mellitus (DM) is associated with increased risk of perioperative complications following lumbar spine surgery, including surgical site infection and venous thromboembolism events (1,2). Type II DM patients have also been shown to have longer hospital length of stay (LOS), higher visual analog scale (VAS) back pain scores, and higher rates of discharge to a rehabilitation or skilled nursing facility following surgery (3). Furthermore, long-term follow-up of patients with DM yields lower patient satisfaction and higher disability scores with recurrent low back pain (4,5). With approximately 29.1 million Americans diagnosed with DM, and direct medical costs estimated at $176 billion in 2012, DM is a major chronic debilitating disease that requires further evaluation of its pathology and sequelae, particularly in preoperative evaluation for spine surgery(6).

Several recent studies have evaluated the morphology of the lumbar paraspinal musculature measured by cross-sectional area (CSA) as a predictor of chronic low back pain and spinal degenerative disc disease (7, 8). Patients with smaller CSA of the lumbar paraspinal musculature, such as the psoas and multifidus, have increased rates of chronic LBP, worse lumbar spine degenerative disease, and increased perioperative morbidity (9). Decreased CSA of the paraspinal musculature can be due to multiple factors, such as age-related atrophy, deconditioning from lack of regular exercise, and inflammation that damages the functional sarcomere units.

Poor patient-reported outcomes following lumbar surgery for DM patients, particularly chronic low back pain and continued disability, may be associated with paraspinal muscle dysfunction (8, 9). The pathogenesis of DM can lead to elevated body mass index (BMI) and peripheral neuropathy, which has been shown to lead to worsening muscular endurance and

proprioception of the lower extremities (10,11). Higher risk of falls and injury during postoperative mobilization can impede recovery of normal ambulatory function for the DM patient following lumbar surgery. Given the multiple systemic effects of type II DM, especially peripheral neuropathy and microvascular disease, we hypothesize that DM may affect the morphology of lumbar paraspinal musculature, leading to disability. The objective of this study is to determine whether there is an association between DM and decreased CSA of paraspinal musculature in patients with chronic LBP and lumbar spine disease who are evaluated for lumbar fusion surgery.

PATIENTS AND METHODS

After institutional review board approval was obtained, a retrospective review of outpatient medical records was performed for patients with lumbar spondylolisthesis who underwent a single level posterior lumbar decompression and fusion. Cohorts were separated based on the preoperative diagnosis of type II DM from the outpatient chart history and physical exam. All of the patients in the DM cohort were insulin-dependent at the time of the evaluation. Hemoglobin A1c measurements could not be recorded for the DM cohort due to the retrospective nature of the study.

The data were collected from seven surgeons from 01/2014-12/2014 with all procedures performed at a single institution. Preoperative patient-reported scores, including the Oswestry Disability Index (ODI), Short Form 12 Physical (SF-12 P), Short Form 12 Mental (SF-12 M) and back pain VAS scores, were included for analysis. Demographic data, including age, BMI, smoking status, history of coronary artery disease and/or congestive heart failure, were also recorded.

Inclusion criteria were any patient above the age of 18 at our institution diagnosed with degenerative lumbar spondylolisthesis, based on the ICD-9 code 721.42, with a preoperative lumbar spine MRI and completed preoperative patient-reported outcome scores. Patients under the age of 18 years, those lacking a preoperative lumbar spine MRI or completed preoperative patient-reported outcome scores, or those with a diagnosis other than degenerative lumbar spondylolisthesis (such as spinal cord injury or metastatic disease) were excluded from the study. Patients were also excluded if they had a myopathic disorder such as muscular dystrophy.

T1-weighted axial MRI images were evaluated independently by two reviewers, both blinded to their respective measurements. Using Sectra Liteview PACS Imaging measurement software, the CSA of the posterior paraspinal musculature (multifidus, iliocostalis, and longissiumus), as well as the psoas CSA, were measured. The measurements were taken through the same axial cut at the midpoint of the L4 vertebral body [Figure 1]. The average of the two measurements was then recorded as the CSA for that muscle.

The total posterior paraspinal CSA, total measured musculature CSA, and ratio of muscular surface area to BMI were also recorded for analysis. This ratio was utilized to help correct for variation in patient height, which impacts the BMI and potentially confounds the CSA of paraspinal musculature due to body habitus. This also helps correct for patients with a significant amount of subcutaneous fatty tissue, which potentially impacts muscular function, patient mobility, and chronic LBP.

Data analysis was performed using SPSS software (Version 22.0 IBM Armonk, NY). Categorical data were analyzed with the Chi Square Test and continuous data with the two-tailed Student t-test. Statistical significance was set with an alpha of 0.05 and power with a beta value

of 0.80. The primary outcome was the comparison of paraspinal muscle CSA between the DM and non-DM cohort.

RESULTS

One hundred and one medical records met inclusion criteria and were reviewed. Thirteen patients were included in the DM group and 88 in the non-DM group. There were no statistical differences in age, BMI, or history of CAD/CHF between the groups. There was a larger percentage of patients in the DM group with a history of smoking relative to the non-DM cohort. There were no significant differences in preoperative ODI, VAS back pain scores, or SF-12 mental/physical health scores between groups [Table 1]. The average time of lumbar spine MRI to outpatient evaluation was 3.6 months. All the muscle CSA measurements were larger in the non-DM group compared to the DM group. The longissimus CSA was significantly decreased in the DM group, with an average surface area of 574.8 mm^2 and 724.3 mm^2 for the non-DM and DM groups, respectively (p=0.004). Total average posterior paraspinal muscle (Iliocostalis, Longissimus, and Multifidus) CSA was 2381.3 $mm^2$and 2077.2 mm^2 for the non-DM and DM group, respectively (p=0.07). Total average measured muscle (psoas included) CSA was 3474.6 mm^2 and 3015.5 mm^2 for the non-DM and DM group, respectively (p=0.08). A significant difference was found in the ratio of total muscle CSA to BMI between groups, with the non-DM group at 115.26 and the DM group at 96.41 (p=0.04) [Table 2].

DISCUSSION

Type II DM continues to be a challenging comorbidity to manage in surgical candidates for lumbar spine pathology. Its systemic manifestations can lead to end organ damage and significant inflammatory response, as well as damage to the peripheral nerves and

microvasculature, especially in the lower extremities (11, 12). These patients have higher obesity rates and metabolic dysfunction that leads to increased fatty tissue in both the subcutaneous and visceral layers of the body, making mobilization and rehabilitation difficult in the immediate postoperative period (11). Sensitization of peripheral sensory nerves can also lead to an elevated pain response and increased requirement for opiate medications during the postoperative period (12). Understanding the risks inherent to this diagnosis and optimizing patient musculoskeletal conditioning prior to surgery may provide significant benefits to the overall success of lumbar decompression and fusion.

There has been increasing interest in recent literature examining the correlation of the morphology, atrophy and/or fatty infiltration, of paraspinal lumbar musculature with lumbar degenerative disc disease, as well as leg pain/weakness, and chronic LBP. Zotti et. al evaluated 66 patients with LBP, neurogenic claudication, and spinal stenosis undergoing posterior lumbar decompression and found significantly worse outcomes at 1 and 2 years in the ODI and Core Outcome Measures Index (COMI) in patients with multifidus CSA <8.5 cm^2 and higher levels of qualitative muscular fatty infiltration (13). Teichtatl et. al performed a cross-sectional study of 72 patients with high intensity LBP and ambulatory dysfunction and measured the CSA and fatty infiltration of the multifidus and grouped erector spinae muscles, and found that fatty infiltration, not CSA, of the paraspinal musculature was significantly associated with type II modic changes and severe, chronic LBP (14). Both the quality and quantity of paraspinal musculature may be important as a predictor of perioperative mobilization following lumbar surgery.

Obesity and insulin resistance that lead to type II DM has been established to increase musculoskeletal inflammation and dysfunction (11). The deposition of glucose into the skeletal muscle and its utilization during aerobic exercise is limited in patients with type II DM due to

failure of the insulin signaling-cascade (15). This dysregulation can lead to the atrophy of lean skeletal muscle and the deposition of fatty tissue in its place, causing sarcopenic obesity, which leads to decreased physical function and activity level (16, 17). Thus, metabolic disorders such as type II DM can create a positive feedback cycle of muscle inflammation and degradation, which can further worsen inactivity and muscular atrophy.

Our analysis found an overall larger CSA of all the paraspinal musculature within the non-DM cohort compared to the DM cohort. The longissimus CSA and total muscle SA to BMI ratio were significantly larger in the non-DM cohort. The results of this analysis demonstrated a morphologic difference in the paraspinal musculature of patients with DM II compared to the non-DM cohort. Although the CSA of the paraspinal musculature was identified no difference was identified in the patient reported outcome measures between both cohorts. This finding suggests that type II DM and its pathologic process leads to atrophy of the paraspinal musculature. Previous studies have established a correlation with paraspinal atrophy and chronic LBP which was not identified during this analysis. Other complications of paraspinal atrophy included an increased risk of poor postoperative mobilization, which can lead to a higher risk of adverse events such as VTE, atelectasis, and leg weakness, thus worsening overall outcomes (17).

To the best of our knowledge, this is the first study to evaluate paraspinal musculature morphology in relation to type II DM in patients with degenerative lumbar spondylolisthesis. The strengths of this study include full preoperative patient-reported outcome scores and lumbar spine MRI imaging within a similar timeframe. We utilized an established method of measuring the CSA of the paraspinal musculature and had two independent measurements of CSA that were averaged to reduce bias. The study cohorts had similar demographic data and represented a

general population of patients with prior advanced imaging who were seeking surgical consultation for lumbar spondylolisthesis.

The limitations of this study include its retrospective nature, which can lead to potential observer and/or reporting bias. Additionally, our study population is limited in size, particularly the DM cohort, but this was intentional in order to focus on insulin-dependent patients that had all of the preoperative data available for analysis. Postoperative outcomes were not completed for this study due to the lack of complete patient-reported outcomes, and the scope of this study was in the preoperation DM cohort. Lumbar spine MRIs were performed at separate locations with different machines, and this could potentially affect image quality and CSA measurements. However, all the imaging data were uploaded into our software system to standardize the measurement process and limit this weakness.

Conclusion

Patients with type II DM showed smaller paraspinal muscle CSA overall, with significantly smaller longissimus muscle CSA and SA to BMI ratio compared to patients without type II DM. Further research should focus on prospectively assessing patients with type II DM after lumbar surgery for LBP and ambulatory dysfunction with long term clinical follow up.

Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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