Analysis of MRI radiomic pelvimetry and correlation with margin status after robotic prostatectomy

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Introduction: *To evaluate the use of preoperative magnetic resonance imaging (MRI) as a predictor of positive margins after radical prostatectomy (RP). This is important as such patients may benefit from postoperative radiotherapy. With the advent of preoperative MRI, we posited that pelvimetry could predict positive margins after RP in patients with less-than ideal pelvic dimensions undergoing robotic-assisted laparoscopic surgery.*
Materials and methods: *After IRB approval, data from patients undergoing RP at our center between 1/1/2018 and 12/31/2019 (n = 314) who had undergone prior prostate MRI imaging (n = 102) were analyzed. All RPs were performed using robotic-assisted laparoscopic technique. Data from the cancer center data warehouse*

were retrieved, to include postoperative T-stage, gland size, responsible surgeon, PSA, patient body mass index, and surgical margin status. These data were analyzed with corresponding pelvimetry data from 91 preoperative scans with complete data and imaging.
Results: *On multivariable analysis, pathologic T-stage (p = 0.004), anteroposterior pelvic outlet (p = 0.015) and pelvic depth (length of the pubic symphysis; p = 0.019) were all statistically correlated with positive surgical margins.*
Conclusions: *With the widespread use of MRI in the initial staging of prostate cancer, automated radiomic analysis could augment the critical data already being accumulated in terms of seminal vesical involvement, extracapsular extension, and suspicious lymph nodes as risk factors for postoperative salvage radiation. Such automated data could help screen patients preoperatively for robotic RP.*

Key Words: robotic prostatectomy, MRI, pelvimetry, margins

Introduction

The finding of positive surgical margins at time of radical prostatectomy (RP) is critical to the patient's future care because it facilitates subsequent postoperative radiotherapy (RT). Three randomized trials[1-3] have

confirmed the benefit of postoperative RT under those circumstances with one trial revealing increased survival.[1]

While anatomical variability of the pelvis has been recognized since the 1930's,[4] much of the resultant literature have been in the obstetrics and gynecology literature. In 2006 Boyle and colleagues[5] proposed that circumferential margins after total mesorectal excision of rectal cancer could be predicted in some women by pelvic measurements. No association was noted in men. We have previously described that men with more gynecoid pelvis shape have more potential prostate motion in RT setup:[6] multivariate analysis

demonstrated that gynecoid pelvis shape and pelvic anteroposterior and right-left dimensions were found to independently predict magnitude and frequency of daily shifts required for RT of prostate cancer.

Some factors have been shown to be predictive on preoperative magnetic resonance imaging (MRI), for instance, membranous urethral length to predict continence.[7] We investigated whether radiomic MRI pelvimetry was associated with margin positivity after RP and performed the current retrospective analysis.

Materials and methods

All patients undergoing RP between 1/1/2018 and 12/31/2019 at Moffitt Cancer Center were analyzed as part of an IRB-approved protocol. Of those 314 patients, 91 with compete data had received prior MRI imaging of the prostate. All patients received robotic-assisted laparoscopic technique; four fellowship-trained urologic surgeons with > 100 cases were responsible for all the procedures. Clinical data were extracted from the cancer center clinical biobank using Honest Broker requirements. Extracted data included Gleason grade group, preoperative PSA, body mass index, surgeon volume, and prostate size. A single investigator reviewed all data to confirm accuracy.

Corresponding preoperative MRI scans were then extracted from PACS by the Quantitative Imaging Core of the Moffitt Cancer Center. The pelvis in each case was semi-automatically segmented on sequential images and reconstructed three-dimensionally. A spheroid shape was virtually fitted inside each reconstructed three-dimensional pelvic structure. Using a previously developed and validated radiomic feature pipeline,[8]

the shape and size characteristics of the segmented pelvis and the spheroid fitted inside it were quantified. The scans were screened for the following reference distances used by Boyle and colleagues:[5] midplane interspinous distance, outlet (AP), outlet (intertuberous) and depth (length of pubic symphysis).

Analysis was performed of the clinical and radiomic data by patient. A binary logistic regression used margin status as a categorical variable, Gleason grade group and pathological T-stage as categorical variables, and the others as continuous variables by quartiles.

Results

Results are included in Table 1. On multivariate analysis, T-stage (p = 0.004), anteroposterior pelvic outlet (p = 0.015) and pelvic depth (length of the pubic symphysis; p = 0.019) were all statistically correlated with positive surgical margins.

Discussion

It is instructive that one clinical parameter and two pelvimetry parameters were associated with positive margins in our analysis, confirming what others have shown. Hong and colleagues reported that men with a deep and narrow pelvis on MRI had a higher rate of positive margins on univariate analysis,[9] and Matikainen and associates also showed that apical prostate depth is an independent risk factor for apical positive surgical margin positivity.[10] Finally, Neill et al showed that transverse pelvic brim distance and intertuberous distance were predictive of positive margins.[11] Thus, data support that a deep pelvis may

TABLE 1. **Clinical and MRI parameters analyzed for correlation with margin status**

Parameter	Metric	MVA significance
Surgeon	1 vs. 2 vs. 3 vs. 4	p = .217
Body mass index	</= 30 vs. > 30	p = .092
GGG	Categorical	p = .926
Gland size	Quartiles	p = .099
pT stage	Categorical	p = .004
PSA	Quartiles	p = 0.595
Interspinous distance	cm	p = 0.15
Outlet AP	cm	p = 0.015
Outlet intertuberous	cm	p = 0.125
Symphysis length	cm	p = 0.019

adversely affect outcomes after RARP. In our data, the association of pathologic T-stage was exclusively due to pT3 disease with an odds ratio of 12.7 (95%CI 2.6-6.2) and was unrelated to gland size. This clearly makes conceptual sense as well. Our sample size (n = 91) is substantial, and clearly these results confirm others' preliminary work.

Conclusions

With the widespread use of MRI in the initial staging of prostate cancer, automated radiomic analysis such as performed here could augment the critical data already being gleaned in terms of seminal vesical involvement, extracapsular extension, and suspicious lymph nodes. □

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