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Cushioning the blow: role of perirenal fat in renal trauma injury severity

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Objectives

To explore the association between perirenal fat thickness (PFT) and renal trauma grade. We hypothesise this association is related to a shock-absorbing effect of adiposity around the kidney.

Patients and Methods

We identified all patients with renal trauma who arrived at the emergency department of a single trauma centre between 2014 and 2020. Radiology images were reviewed to measure the PFT around the uninjured kidney due to disrupted PFT around the traumatised kidney. Patients with no available images or penetrating trauma mechanism were excluded. Logistic regression was used to assess the relation between PFT and high-grade renal trauma (HGRT; defined as American Association for the Surgery of Trauma Renal Grade IV–V), adjusting for age, sex, and Injury Severity Scale (ISS).

Results

A total of 150 patients with renal trauma were included. The median (interquartile range) age was 38.5 (26–52) years and 106 (70.7%) were males. The PFT ranged between 2.1 and 50.1 mm, and 31 (20.7%) had HGRT. Interestingly, PFT only mildly correlated with body mass index (BMI; Pearson correlation coefficient 0.42, $P < 0.001$). Those with HGRT had significantly lower PFT compared to those without HGRT (median 9.5 vs 11.9 mm, $P = 0.047$). In the multivariable analysis adjusting for age, sex, and ISS, increasing PFT was associated with decreased odds (odds ratio 0.91, 95% confidence interval 0.84–0.98; $P = 0.015$) of HGRT.

Conclusion

Increasing PFT is associated with lower risk of HGRT following blunt injury. These results support a protective cushion role of adiposity in renal trauma. Notably, PFT was not strongly correlated with BMI, underscoring limitations of BMI in measuring adiposity.

Keywords

kidney trauma, high-grade renal trauma, perirenal fat, urological trauma, #UroTrauma, #Urology

Introduction

Kidney injury is associated with significant morbidity and mortality [1]. Blunt renal trauma accounts for 71%–95% of renal trauma cases and are primarily caused by motor vehicle collisions and falls in the adult population [1]. Renal injury grade is strongly associated with patient outcome: prior reports indicate that 0% of the American Association for the Surgery of Trauma (AAST) Grade I injuries required surgery, whereas nearly 86% of Grade V injuries end in nephrectomy [2]. As the management of renal trauma is highly dependent on severity, understanding the factors that contribute to high-grade renal trauma (HGRT) is essential.

Several studies have supported a protective role of adiposity in reducing damage in blunt trauma [3–7]. Recently, the risk of HGRT was shown to be associated with body mass index (BMI) in patients sustaining blunt trauma, with higher BMI category conferring lower risk of HGRT in a stepwise manner

[8]. BMI has limited ability in quantifying adiposity, especially being unable to differentiate fat tissue from other types of tissue [9]. Perirenal fat has an essential role in providing kidney mechanical support and thus may represent a more accurate mediator of this protective effect [10,11].

We aimed to assess the association between perirenal fat thickness (PFT) and HGRT in patients with blunt renal trauma. We hypothesised that increasing PFT would decrease the deceleration and acceleration forces exerted on the renal parenchyma and vasculature, leading to less severe injury.

Patients and Methods

Data Source

Following Institutional Review Board approval, we queried our prospectively maintained trauma registry at the Zuckerberg San Francisco General Hospital and Trauma Center for all patients who arrived at the emergency department with renal trauma between 2014 and 2020 (274 patients). Those with a penetrating trauma mechanism were excluded (83 patients). Those with bilateral renal injury were excluded (no patients). We extracted patient demographics (age, sex, race, BMI) and injury characteristics (Injury Severity Scale [ISS] [12]), protective devices at time of trauma (airbag, lap belt), 2018 renal AAST injury grade [13]).

Perirenal Fat Thickness Measurement

Our primary exposure variable was PFT. We reviewed contrast-enhanced axial CT images with 1-mm cuts obtained at the time of trauma. PFT was defined as the maximum perpendicular distance between the kidney's posterior surface and the external margin of iliopsoas at the level of renal vein (Fig. 1) [14]. We measured distance using the standard 'Measurement' tool of the PACS XERO Viewer software (AFGA Healthcare, Greenville, SC, USA). All measurements were performed by a single investigator (J.L.L.). The PFT was measured on the same CT scan where the initial renal trauma was diagnosed. PFT was measured in the uninjured kidney due to concerns for fat disruption during trauma. We performed a sensitivity analysis by screening patients' charts for abdominal CT scans performed within 1 year of trauma (which was available for five patients). We measured PFT around the injured kidney in these images and compared to those measured at time of trauma; measurements were not significantly different (mean difference = 0.8 mm, Appendix A). If a patient presented with a right renal trauma, the left PFT was used at the time of trauma and the sensitivity analysis compared that value to the not-yet-injured right kidney PFT. In addition, we sampled 10 patients without renal trauma to compare PFT around right and left kidneys. We were able to retrieve imaging in nine out of those, which yielded a mean difference of 1.24 mm (Appendix B).

To assess for intrarater reliability of PFT measurement, a sensitivity analysis was performed by randomly selecting 30 subjects for which the PFT measurements were re-performed by the same investigator (J.L.L.) who performed the original measurements. The reviewer was blinded to the original measurement values. The mean absolute difference between the original and repeated values was 0.87 mm. Detailed results of this sensitivity analysis are described in Appendix C.

Statistical Analysis

The Pearson correlation coefficient was calculated to determine the degree of correlation between PFT and BMI. Our primary outcome was HGRT, defined as AAST Renal Grade IV–V. AAST Renal Grades I–III were considered low-grade renal trauma (LGRT). The PFT distribution was compared among those with and without HGRT using Mann–Whitney *U*-test. Logistic regression was used to assess the association between PFT and HGRT, adjusting for age,

Fig. 1 Sample images of PFT measurement (in mm) around the uninjured kidney at the time of trauma.

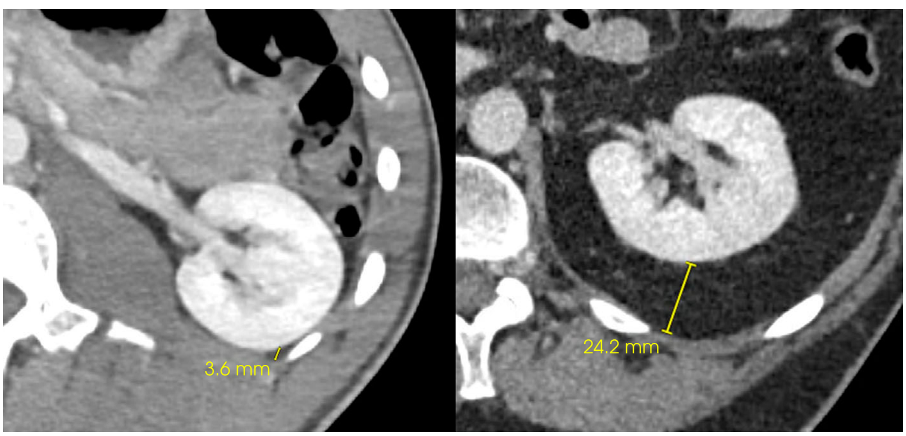
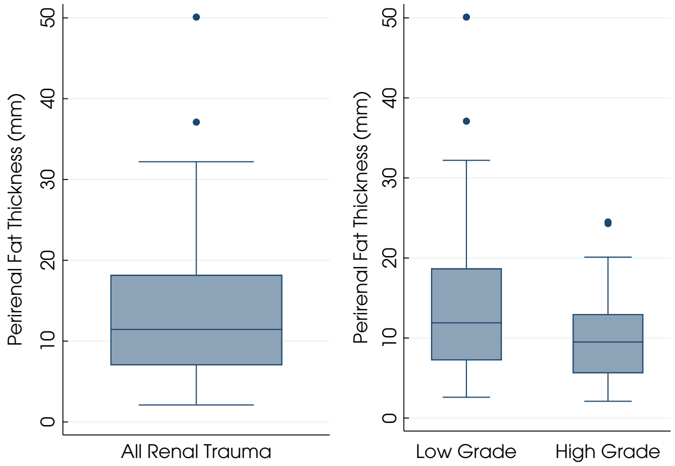


Fig. 2 Box plots representing PFT distribution in total population, and stratified by HGRT vs LGRT, $P = 0.04$ (Mann–Whitney *U*-test). Median values, IQRs, and range of values excluding extreme points are shown. Extreme values more than 1.5 T (Q3–Q1) away from either Q1 or Q3 are depicted as individual points.



sex, ISS, and protective devices. Linearity assumption for PFT in the logistic model was assessed using restricted cubic splines analysis. Model 'goodness of fit' was assessed using the Hosmer–Lemeshow goodness-of-fit test [15]. All statistical analysis was performed using Stata 17 (College Station, TX, USA) and all *P* values were two-sided with a $P < 0.05$ considered statistically significant.

Results

We identified 150 patients who met all inclusion criteria. The median (interquartile range [IQR]) age was 38.5 (26–52) years and 106 (70.7%) were males. The PFT had a skewed distribution (Fig. 2), with a median of 11.45 mm and an outlier-excluding range of 2.1 mm to 32.2 mm. Only two patients had a PFT >32.3 mm. Interestingly, PFT was only mildly positively correlated with BMI, with a Pearson correlation coefficient of 0.42 (Appendix D). In all, 27 patients (18%) had protective devices at time of trauma (airbag present, 20; lap belt, seven). Males had a higher median PFT and wider PFT distribution compared to females (median [IQR] 12.25 [7.8–19.9] vs 8.5 [5.6–12.65] mm). However, males also had a slightly higher BMI (median [IQR] 25.4 [22.3–29.4] vs 24.8 [20.5–30.1] kg/m^2).

A total of 31 patients (20.7%) had HGRT compared to 119 (79.3%) with LGRT. Those with HGRT had a significantly different distribution of PFT compared to LGRT patients (median [range] 9.5 (2.1–24.5) mm in HGRT vs 11.9 (2.6–50.1) mm in LGRT, $P = 0.04$; Fig. 2). In the adjusted logistic regression analysis, a 1-mm increase in PFT was associated with a 9% decrease in odds of HGRT (95% CI 2%–15.8%, $P = 0.016$; Table 1). Figure 3 shows the

Fig. 3 Logistic regression model adjusted probabilities of HGRT in relation to PFT. Shaded areas represent 95% CIs.

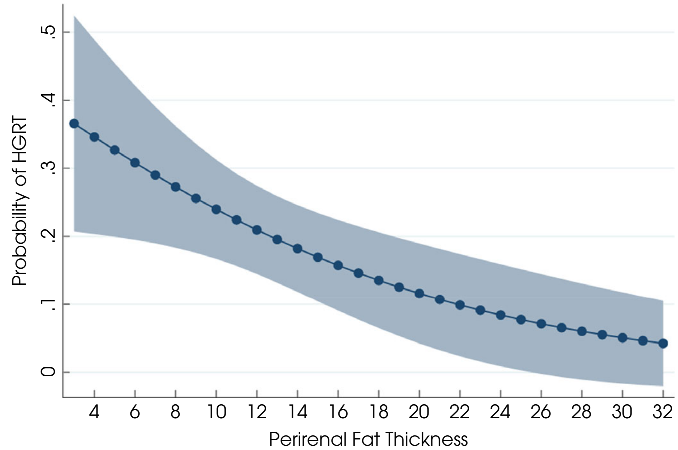


Table 1 Multivariable logistic regression model for the association between PFT and HGRT controlling for age, sex, ISS, and presence of protective devices.

	OR (95% CI)	*P*
PFT (per mm)	0.91 (0.84–0.98)	**0.015**
Age	1.01 (0.98–1.03)	0.308
Male sex	1.29 (0.49–3.4)	0.6
ISS	1.04 (1.01–1.07)	**0.008**
Protective devices	0.81 (0.24–2.8)	0.752

Bold values statistically significant at P < 0.05.

regression model adjusted predicted probability of HGRT in relation to PFT.

Discussion

We report novel insight with implications for the pathophysiology of blunt renal trauma. We found that increasing PFT was associated with lower risk of HGRT. We had sought to specify and expand on the association between higher BMI and lower HGRT that was previously reported [8]. Anatomically, the kidney is encased by fat and Gerota's fascia in the retroperitoneum, with primary attachments being the renal pedicle and PUJ. Proposed mechanisms of blunt renal injury include deceleration forces and damage of these structures or acceleration forces causing kidney collision against surrounding structures [16]. Thus, increased adipose mass around the kidney may insulate the kidney by absorbing these forces or acting as a physical cushion surrounding the renal parenchyma.

We hypothesised that obesity would be highly correlated with increased fat around the kidney, which in turn would provide additional protection. Interestingly, our data revealed only a mild correlation between BMI and PFT, where mean PFT increased with higher BMI, but the slope of increase was less dramatic than hypothesised. We interpret this finding in context of the imperfect accuracy of BMI as an adiposity measure. Higher BMI potentially reflects more adiposity or more muscularity [9], thus the total effect in a population could be that PFT increases with BMI at a moderate rate. Previously we reported that higher BMI category was associated with lower risk of HGRT in a sample of >15 000 patients [8]. Patients in a higher BMI category are expected to have, on average, more adiposity (including PFT) than those in a lower BMI group. This can coexist with the fact that not every patient in a higher BMI category should have more PFT than every patient in a lower BMI category, which we demonstrate in this study. This suggests PFT may be a more accurate predictor of the protective effects of adipose tissue on high-grade injury.

Few studies have evaluated the role of adiposity in trauma using measures other than BMI. Consistent with our findings, a recent study of 592 patients involved in motor vehicle collisions found that a higher ratio of visceral fat area to total body area was associated with decreased odds of serious abdominal injury, defined as Maximum Abbreviated Injury Scale score ≥3 (OR 0.06, 95% CI 0.008–0.509; $P = 0.009$) [17].

Limitations of our analysis include possible residual confounding as numerous factors interplay in trauma severity. Perirenal fat is not the only adipose tissue between the kidney and source of impact, and we did not account for other measures of adiposity such as total body fat or visceral fat, or measures of muscularity. Our relatively small sample size is not expected to accommodate such complex analysis. Also, there could have been imperfect measurement of PFT, as measurements were taken around the uninjured kidney. Although this was performed due to fat disruption around the traumatised kidney the sensitivity analysis performed was reassuring. Additionally, we do not know if anatomical anomalies (e.g., presence of hydronephrosis, renal masses or cysts, stones, or pre-existing drains) affected PFT measurement. Our series included patients with anomalies but lacked the numbers to comment on these substantively. Finally, some patients were excluded due to missing radiological images. These were probably rushed to the operating room or expired briefly after arrival to emergency department, and so might have a higher likelihood of HGRT, possibly inducing some selection bias in our sample.

Increasing PFT is associated with lower risk of HGRT following blunt injury. These results support a protective cushion role of adiposity in renal trauma. Notably, PFT was not strongly correlated with BMI, underscoring limitations of BMI as an accurate adiposity measure.

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None.

Conflict of Interest

All authors declare no conflict of interests.

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None.

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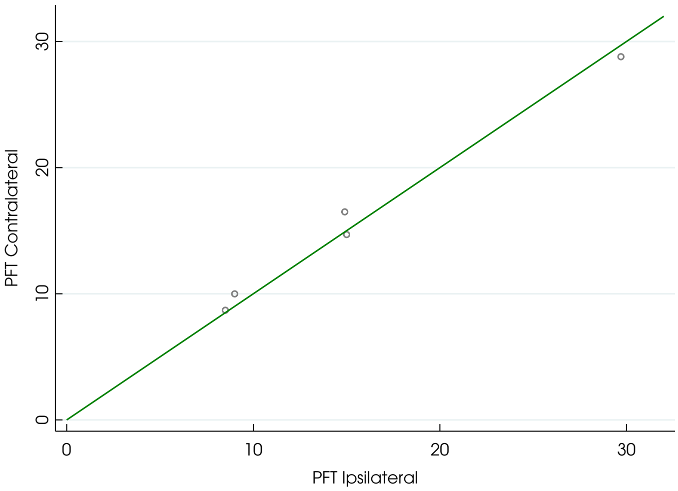
Appendix A

Perirenal fat thickness measurement (in mm) around the uninjured kidney at the time of trauma 'PFT contralateral' compared to that measured around the injured kidney within a year after trauma 'PFT ipsilateral'



	PFT contralateral, mm	PFT ipsilateral, mm	Absolute difference, mm
Patient 1	8.7	8.5	0.2
Patient 2	10	9	1
Patient 3	14.7	15	0.3
Patient 4	16.5	14.9	1.6
Patient 5	28.8	29.7	0.9

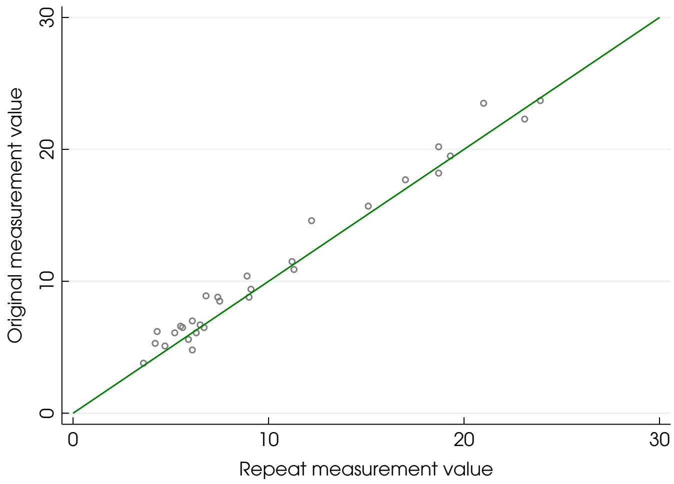
Appendix B

Comparison of PFT around the right and left kidneys in patients without renal trauma.

	PFT right kidney, mm	PFT left kidney, mm	Absolute difference, mm
Patient 1	11.9	14.1	2.2
Patient 2	13.6	12.2	1.4
Patient 3	2.2	1.9	0.3
Patient 4	22.8	25.6	2.8
Patient 5	9.4	12.7	3.3
Patient 6	11.5	10.6	0.9
Patient 7	11.4	11.4	0
Patient 8	8.4	8.6	0.2
Patient 9	15.7	15.6	0.1

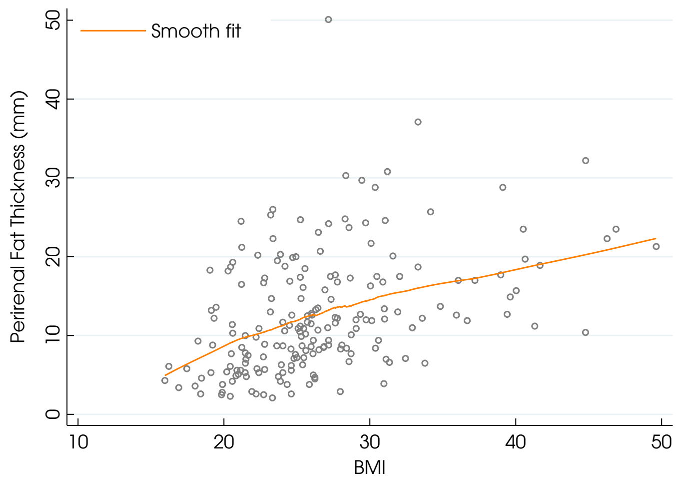
Appendix C

The PFT values (in mm) obtained in original vs repeated measurements.



Appendix D

The PFT vs BMI. Orange line represents the locally weighted scatterplot smoothing (LOWESS) curve.



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Abbreviations: AAST, American Association for the Surgery of Trauma; BMI, body mass index; HGRT, high-grade renal trauma; IQR, interquartile range; ISS, Injury Severity Scale; LGRT, low-grade renal trauma; OR, odds ratio; PFT, perirenal fat thickness.

