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Penetrating Renal Trauma: A Review of Modern Management

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Abstract

Background: To minimize acute kidney injury, trauma surgeons, urologists, and surgical intensivists alike have utilized conservative approaches when managing penetrating renal trauma. As this review of the literature demonstrates, even Grade IV penetrating renal injury with extravasation of contrast can be successfully managed with conservative therapy.

Methods: A systematic review of currently published studies was performed following standard guidelines. The search was conducted through PubMed and included studies published in English that pertained to penetrating renal trauma. Studies were then limited to those published since 1980 that contained information regarding aetiology, diagnosis, and management of penetrating renal trauma were considered. Further selection and categorization was based on inclusion of information regarding outcomes and approach to management of penetrating renal trauma. Given the paucity of Level I and Level II evidence, all studies published over the last 50 years were initially screened for relevance.

Results: Our initial data search yielded 350 potentially relevant studies; of these, approximately a dozen met the selection criteria based on inclusion of information regarding mortality, rates of complication, and approach to management.

Limitations: Limitations of this article are like all review articles: the dependence on previously published research and availability of references as outlined in our methodology. There is also a lack of published Level I and Level II studies specific to this topic in the world's literature.

Conclusion: Management of penetrating renal trauma is complex and challenging. Literature published over the past five decades supports the fact that selective nonoperative management of penetrating renal injuries can and should be employed in the clinically stable patient. A proper diagnosis should be obtained to help objectively grade the injury and guide further management.

Keywords: Penetrating renal trauma; Nephrectomy; Renal salvage; Laparotomy; Selective management

Introduction

Trauma accounts for more than 120,000 deaths annually and is the leading cause of death for those aged 1-44 years in the United States [1]. Specifically, trauma of the genitourinary tract accounts for 1% to 5% of all patients with abdominal injuries [2,3]. Renal injury itself may result from penetrating, blunt, or iatrogenic mechanisms and is graded by the American Association for the Surgery of Trauma Organ Injury Scale (AAST-OIS) [4]. Surgeons often utilize this scale, in addition to information regarding number of associated injuries to determine the appropriate approach to management [5,6]. However, the paradigm related to the management of penetrating renal trauma has evolved over the past several decades and current approaches call for a review of the existing literature.

Methods

A thorough search of the world's literature following standard guidelines was conducted through PubMed. The search term "penetrating renal trauma" was queried and specific studies were selected by relevance and inclusion of data regarding aetiology, diagnosis, and management of penetrating renal trauma.

Results

A literature search using PubMed returned 450 potentially relevant articles when the search term "penetrating renal trauma" was entered. There were 350 studies published in English from 1980 to the present, and the ones selected were based on inclusion criteria: the presence of mortality rate,

complication rate, and management technique of penetrating renal trauma **(Table 1).**

Table 1 Summary of penetrating renal trauma in the literature.

Year	Authors	Sample Size, n	Mortality (n%)	Complications (n%)	Operative (n%)	Conservative (n%)
1997	Wessells [7]	120	--	10 (8.3)	79 (65.8)	41 (34.2)
1999	Armenakas [8]	199	4 (2.0)	2 (1.0)	108 (54.3)	92 (46.2)
1999	Gonzalez [9]	56	1 (1.8)	--	52 (92.9)	4 (7.1)
2002	Nicol [10]	50	3 (6.0)	2 (4.0)	37 (74.0)	13 (26.0)
2004	Kansas [11]	93	18 (19.4)	14 (15.1)	74 (79.6)	19 (20.4)
2006	Davis [12]	25	0 (0.0)	9 (36.0)	11 (44.0)	14 (56.0)
2006	Wright [13]	1573	251 (16.0)	--	333 (21.2)	1240 (78.8)
2009	Edwards [14]	54	8 (14.8)	30 (55.6)	54 (100.0)	0 (0.0)
2011	Bukur [15]	59	--	7 (11.9)	35 (59.3)	24 (40.7)
2011	Bjurlin [16]	97	9 (9.3)	2 (2.1)	58 (59.8)	39 (40.2)
2012	Moolma [17]	70	--	4 (5.7)	25 (35.7)	47 (67.1)
2013	Shoobridge [25]	13	--	--	1 (7.7)	12 (92.3)
2015	Darwish [56]	57	3 (5.3)	12 (21.1)	46 (80.7)	11 (19.3)
Average Values	--	--	13.50%	11.20%	37.00%	63.10%

Discussion

Background

Renal injuries have a wide range of mortality (0% to 19.4%) and morbidity (1% to 55.6%) **(Table 1)** [7-17]. More than 95% of kidney injuries are considered minor and non-operative therapy has been successfully utilized without serious complications [1]. Surgical intervention is recommended for potentially fatal injuries such as severe destruction of the pelvicalyceal system (PCS), renal pedicle injury or avulsion, and renal shattering [1]. The use of objective diagnostic imaging has aided in selection of renal management and reduced the overall incidence of surgical exploration. Management of renal injury is challenging as it usually occurs as part of multisystem trauma. If overlooked, these injuries can lead to severe morbidity. Although penetrating kidney injuries have been successfully treated with non-operative measures, surgical exploration has historically been indicated for more severe injuries [18,19].

Diagnosis

Ultrasonography has successfully been utilized in the trauma setting for decades and is reliable for investigating hemoperitoneum in penetrating abdominal injuries [20]. The Focused Assessment Sonography in Trauma (FAST) technique yields rapid, bedside results that have the capacity to dictate further care without delaying treatment. Although ultrasound imaging offers superior quality in the detection of a laceration, it lacks accuracy in assessing actual extent and depth of injury [21]. The specificity of FAST exams approaches 100% in penetrating abdominal trauma, but sensitivity is highly variable. Accuracy of the exam is highly patient- and operator-dependent and negative results do not rule out injury [22].

Helical computed tomography (CT) with intravenous contrast is the preferred diagnostic modality in hemodynamically stable patients suffering from penetrating abdominal injuries [20]. If clinical suspicion is high and the patient remains hemodynamically stable, contrast can additionally be provided through oral and rectal routes to better define potential gastric, enteric, or colonic injuries. Radiologist experience, scanner accessibility, and image quality are all key variables that determine the usefulness of this technique [20]. CT is the gold standard for diagnosing stable patients suspected of having a renal injury [21]. The general advantage of CT is its ability to delineate precise injury location and the exact structures involved. It forms the basis for identifying renal contusions and devitalized segments through good visualization of the abdominal organs and retroperitoneum [23,24].

Non-operative management

In the current literature, non-operative management (including bed rest/observation, percutaneous drainage, and angioembolization) has been utilized for penetrating renal trauma 64% of the time on average with a range of 0% to 78.8% **(Table 1)** [7,17,25]. Although once considered inappropriate, conservative or non-operative management for penetrating abdominal trauma is now a viable option for hemodynamically stable patients without peritoneal signs [26].

Several studies have substantiated the claim that management of penetrating renal trauma with a conservative approach may be beneficial [7,8,11,12,17,27]. A prospective, randomized study investigated the effects and benefits of non-operative management in patients with stab wounds to the kidney. Results showed that in lower grade injuries, patients who did not undergo surgical intervention were discharged from the hospital four days sooner with no increased risk of delayed need for nephrectomy [28]. This was also demonstrated through a 20-year retrospective analysis, which determined that stab wound injuries involving the kidney could successfully be managed non-operatively, and without secondary incident [8].

In a study conducted to determine the effectiveness and feasibility of conservative management in penetrating abdominal trauma, 95 patients with haematuria were investigated. Of the total sample, 80.4% (75) were found to have renal injuries at the time of surgery or based on prior imaging. Non-operative management was successfully carried out in 47 patients who had sustained 49 renal injuries. Thirteen of the 47 patients did undergo a formal laparotomy for other injuries, but without renal exploration. The 49 renal injuries managed non-operatively were graded as follows: Grade I – 6 (12%), Grade II – 17 (35%), Grade III – 17 (35%), Grade IV – 9 (18%), and Grade V – 0 (0%). In these patients, 9% (3) had limited morbidity in the form of pseudoaneurysm (1) or arteriovenous fistula formation (2). There was no conversion to operative management in patients who were initially selected for non-operative management [17]. Selective non-operative management has been shown to decrease hospital length of stay, length of ICU stay, rate of transfusion, and mortality, while maintaining complication rates like those seen in operative management [16,17,29-35].

Renal artery embolization (RAE) is a newer method included in the scope of non-operative approaches to management for renal trauma. Over the last 20 years, both technology and technical skill pertaining to selective embolization have shown promise in the trauma setting [36]. Very little dedicated research has been performed to evaluate the role for RAE in the setting of penetrating renal trauma. Other studies suggest that it may be best use in cases of lower grade renal injury (I-III), especially ones that demonstrate persistent bleeding after injury [37-40]. There is limited and mixed data to support its use in Grade V injuries with some showing moderate success and others showing complete failure [36]. When dealing with high grade (IV or V) penetrating renal trauma, the likelihood of concomitant damage to surrounding organs is high and often necessitates exploration of the abdomen. When this occurs, angioembolization, though capable of mitigating the renal bleed, may only delay definitive treatment of other injuries [41,42]. Acute complications of embolization include iatrogenic puncture or laceration of the renal artery [43] and "post-embolization syndrome" which is characterized by hyperpyrexia secondary to ischemic renal tissue [44]. Long-term complications include refractory hypertension, renal abscess, and decreased renal function [45].

Operative management

Increased injury grade and hemodynamic instability are factors that indicate the need for surgical intervention. In a review of the current literature, operative management was utilized in 34% of cases on average with a range of 7.7% to 100% **(Table 1)** [7-17,25]. Specifically, utilization of surgical intervention was demonstrated in a retrospective review that examined 97 patients with renal injury. Of the 25 patients presenting with penetrating renal trauma, operative management was utilized in 11 and included: renal repair (2), partial nephrectomy (1), and complete nephrectomy (8) [12]. Notable predictors of nephrectomy in this study population were the presence of hemodynamic instability upon admission, significant blood transfusion within 24 hours, and higher renal laceration grade (4.6 ± 0.5 vs. 2.7 ± 1.6) [12]. Nephrectomy was not indicated in patients with mild to moderate penetrating kidney injuries. Nephrectomy was ultimately required in 50% (6/12) of injuries classified as Grade IV and 88% (7/8) classified as Grade V [12].

The necessity of gaining vascular control of the renal pedicle during a renal exploration is controversial. Some believe that this places the kidney at risk for thrombosis and may ultimately necessitate nephrectomy when the organ may have otherwise been salvaged [9]. However, many others believe that vascular control of the pedicle is imperative to control haemorrhage and provides better visualization.

Renal salvage may be achieved through either partial nephrectomy or tenorrhaphy. Before determining that the kidney is salvageable, the organ should be evacuated of hematoma and carefully inspected [46,47]. Open collecting systems and lacerated vessels should be identified and devitalized parenchyma should be debrided. Closure of the collecting system should be done with absorbable suture to prevent the creation of a nidus for possible stone formation [46,47]. The utilization of tenorrhaphy is most applicable when the injury does not involve either of the poles, but is instead located through the middle portion of the parenchyma. While this procedure is safe and durable, patients undergoing tenorrhaphy may be at a slightly increased risk for local kidney-related complications as compared to other therapeutic approaches [48]. However, consistent data to support this idea is lacking, as others have shown complication-free outcomes in large populations [10,31].

In severe injuries, nephrectomy may be the only remaining option for management. An exhaustive examination of the National Trauma Data Bank performed by Wright in 2006, demonstrated that regardless of the mechanism of injury, the most consistent predictor of nephrectomy was the presence of a Grade V lesion [13]. To complete the nephrectomy, ligation of the ureter and renal artery and vein should be performed. As the gonadal veins frequently drain into the renal veins (most commonly on the left), care should be taken to also ligate the gonadal vessel to limit consequential damage of the associated gonadal organ. It should be noted that when nephrectomy is considered, knowledge of the presence or absence of a contralateral kidney is imperative [49].

Complications

Both short-term and long-term complications may arise following renal trauma. Common complications include hypertension, urinary tract infection/abscess formation, urine leak/urinoma formation, arteriovenous fistula formation and pseudoaneurysm formation [50]. The renin-angiotensin-aldosterone system (RAAS) is responsible for renal trauma-induced hypertension, so the initial treatment modality should include either an angiotensin converting enzyme inhibitor (ACEI), or an angiotensin receptor blocker (ARB) [50]. If hypertension is refractory to medical intervention, concern should be raised that a lesion, such as a hematoma, is impeding renal blood flow and thus, causing the elevation in blood pressure. In this case, the injured kidney may be best served through exploration for capsulotomy, partial nephrectomy, or complete nephrectomy [50].

Extravasation of urine is the most common complication associated with renal trauma [50]. In most patients, extravasation will resolve without significant intervention. However, if the urinary leakage does not resolve on its own, a percutaneous nephrostomy or retrograde stent can be placed to take pressure off the injured segment [51].

Urinary tract infection is also a common complication found among patients having sustained renal trauma requiring management in the intensive care unit [5]. Perinephric abscesses are known to develop and, if left untreated, can be fatal when located in the upper and subphrenic abdominal regions [52]. Postoperative abscesses are the leading cause of infectious lesions within the perinephric space. Like intraperitoneal abscesses, retroperitoneal space abscesses should be diagnosed and treated promptly. These abscesses are effectively managed with the use of appropriate antibiotics, percutaneous drainage, and aspiration [53]. The development of either an arteriovenous fistula or a pseudoaneurysm is uncommon but usually related to stab wound injury of the kidney. Identification and diagnosis of these complications can be made via angiography or contrast-enhanced CT and the treatment for both potential sequelae of penetrating renal trauma is selective angioembolization [54].

Limitations

Limitations of this article are like all review articles: the dependence on previously published research and availability of references. Also, there is a paucity of Level I and Level II evidence regarding this specific traumatic injury.

Conclusion

Trauma is a leading cause of mortality in the United States [1]. Specifically, renal injury occurs in 1% to 5% of abdominal trauma [2,3]. Penetrating renal trauma is commonly associated with other abdominal injuries requiring the conventional approach of emergent laparotomy and renal exploration to be utilized. Literature produced over the past two decades, however, suggests that non-operative management (observation, drainage, and angioembolization) of penetrating renal injuries can be utilized successfully if the patient is hemodynamically stable. In contrast, and consistent with historical practice, hemodynamically unstable patients require an expedient exploratory laparotomy. Renal trauma is associated with known complications including hypertension, extravasation of urine, urinary tract infection, and perinephric abscess that should be managed with close follow-up. In summary, management of penetrating renal trauma is complex and challenging, however proper diagnosis obtained using modern technology may help objectively grade the injury and guide subsequent approaches to management.

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