

# Management of Traumatic Abdominal Inferior Vena Cava Injuries and Predictors of Its Mortality

Rashid Usman,<sup>1\*</sup> Muhammad Jamil,<sup>1</sup> Saira Ambreen,<sup>1</sup> Raoon Khan,<sup>1</sup> Shahid Majeed<sup>1</sup>

## ABSTRACT

**Objective** To document the experience of management of traumatic abdominal inferior vena cava (IVC) injuries and the impact of various perioperative variables on its mortality.

**Study design** Cross sectional study.

**Place & Duration of study** Between January 2005 and January 2019

**Methodology** All consecutive patients with IVC injuries fulfilling the inclusion criteria, were included. Demographics, management and perioperative variables were recorded.

**Results** Out of 42 patients with mean age  $26.8 \pm 3.3$  year, there were 32 (76.2%) males. Penetrating injury was the cause in 28 (66.7%) patients. Most common injury site was infra renal segment (76.2%). Commonest type of injury was partial laceration ( $n=12$  - 28.5%) and most common repair performed was primary venorrhaphy in 14 (38.9%) cases followed by ligation in 10 (27.8%). Overall mortality rate was 42.8% ( $n=18$ ). In terms of repair; the mortality rate was highest for ligation (60%), mechanism of injury [OR 1.11 (95% CI: 1.03-1.38),  $P = 0.002$ ], systolic BP [OR 1.11 (95% CI: 1.02-1.33),  $P = 0.002$ ], high serum lactate levels [OR 1.29 (95% CI: 1.09-1.44),  $P = 0.002$ ], concomitant solid organ injury [OR 1.05 (95% CI: 1.01-1.35),  $P = 0.002$ ], concomitant extra abdominal injuries, PRCT [OR 1.21 (95% CI: 1.11-1.67),  $P = 0.037$ ] and prolonged ICU stay [OR 1.09 (95% CI: 1.02-1.44),  $P = 0.003$ ]; were found to be independent positive predictors of higher mortality.

**Conclusions** Abdominal IVC injury is associated with high mortality with supra hepatic injuries being almost fatal. Best results are achieved with primary repair and ligation has poor outcome.

**Key words** Inferior vena cava, Vascular injury, Abdominal trauma, Venous injury.

## INTRODUCTION:

Injuries to the abdominal IVC although rare but are associated with high mortality of 34-70%.<sup>1,2</sup> Of these, blunt injury has the highest mortality rate (63%) followed by penetrating (48%) and iatrogenic

injuries.<sup>1,3</sup> IVC injuries most commonly affect the infra-renal part (39%).<sup>2</sup> Paradoxically, mortality rates of infra renal IVC are the lowest (23%).<sup>4,5</sup> Current treatment options include ligation, repair, shunting and intravascular balloon placement.<sup>6</sup> Postoperative survival rates are further dependent on many factors including the level of injury, number of associated injuries, hemodynamic status of the patient upon arrival and the amount of blood loss.<sup>1</sup>

There is paucity of literature on this subject and non-availability of vascular surgeons in trauma setting is another hurdle in optimal management of such injuries. We present our experience of dealing with IVC injuries in tertiary care setups along with assessment of the impact of various injury related

<sup>1</sup> Department of Vascular Surgery Combined Military Hospital Lahore.

## Correspondence:

Dr. Rashid Usman<sup>1\*</sup>  
Department of Vascular Surgery  
Combined Military Hospital  
Lahore  
E mail: drrashidusman@yahoo.com

and operative variables on mortality.

#### METHODOLOGY:

This was a cross sectional study in which all patients with inferior vena cava injuries presenting between January 2005 to January 2019; in level 1 Military trauma centres across Pakistan namely Combined Military Hospital Quetta, Lahore, Peshawar and Rawalpindi were included. Injuries to the IVC were classified according to American Association for the Surgery of Trauma Organ Injury Scale (AAST – OIS) for abdominal vascular injury.<sup>7</sup> According to this scale, IVC injuries fall in grade 3 (infra renal), grade 4 (supra renal and infra hepatic) or grade 5 (retro hepatic or supra hepatic).

Patients were resuscitated according to standard trauma guidelines. Variables of interest documented were vascular re-interventions, complications and mortality. The patients were divided in two groups; survival versus expired. Statistical analysis was

done with SPSS Version 17.0 (SPSS® Inc., IL, USA). The numerical variables were expressed as means and standard deviations (SD) and categorical data was expressed as frequency and percentage. Continuous variable were compared using Student's t-test. P-values of less than or equal to 0.05 were considered statistically significant. Univariate logistic regression was performed to assess the impact of demographic, operative and injury related variables. Multivariate logistic regression was performed for those variables where the P-value in univariate regression was less than or equal to 0.2.

#### RESULTS:

A total of 42 patients were included in this study. Baseline demographics of patients and mechanism of injury are described in table I. The grade of injury according to AAST – OIS scale, the types of vascular injury and their repairs are given in table II.

Concomitant abdominal solid organ injuries were

<b>Table I: Baseline Characteristics of The Patients and Their Mechanism of Injury</b>	
Age (in Years) [Mean ± SD]	26.8 ± 3.3
Gender Male [n, (%)]	32 (76.2)
Gender Female [n, (%)]	10 (23.8)
GCS score at presentation [Mean ± SD]	10 ± 3
<b>Trauma scores at presentation [Mean ± SD]:</b>	
Injury Severity Score (ISS)	19 ± 11
Revised Trauma Score (RTS)	9 ± 3
<b>Mechanism of Injury [n, (%)]</b>	
Penetrating:	28 (66.7)
Shrapnel of blast	12 (28.5)
Gunshot	10 (23.8)
Stab	6 (14.3)
Blunt:	14 (33.3)
Motor vehicle accident	8 (19)
Crush injury	4 (9.5)
Motor cycle accident	2 (4.7)
Hospital stay [Mean ± SD]	18 ± 4
ICU stay in days [Mean ± SD]	14 ± 4
<b>Concomitant procedures [n, (%)]:</b>	
Thoracotomy	2 (4.7)
Craniotomy / Burr hole	6 (14.3)
Fasciotomy	20 (47.6)

**Table II: Vascular Injuries and Their Operative Repairs**

<b>Grade of IVC Injury (AAST – OIS Scale)</b>	<b>[n (%)]</b>
Grade 3 - Infra renal	32 (76.2)
Grade 4 - Infra hepatic but supra renal	4 (9.5)
Grade 5 - Supra hepatic	6 (14.3)
<b>Type of Vascular Injury</b>	<b>[n (%)]</b>
Laceration	12 (28.5)
Partial wall loss	10 (23.8)
Complete Transection	6 (14.3)
Shattered IVC	14 (33.3)
<b>Vascular Repair (in 36 cases only)</b>	<b>[n (%)]</b>
Primary Repair (Venorrhaphy)	14 (38.9)
Ligation	10 (27.8)
Autologous Vein Graft	6 (16.6)
Synthetic Graft (Dacron/Polyester Woven)	6 (16.6)

found in 28 (66.7%) patients, with liver in 20 (71.4%) and spleen in 14 (50%) as commonest organs injured. All patients were admitted in ICU [mean stay 14 ± 4 days (range 1 – 21)]. Total hospital stay was 18 ± 4 days (range 7 – 30).

Mortality rate at 3 months was 42.8% (18/42) including 6 cases of poly trauma who expired on table at surgery and 12 expired later in ICU due to multi organ failure. In terms of injury site; all patients with grade 5 injury expired (6/6, 100%), followed by grade 4 (2/4, 50%) and grade 3 (10/32, 31.2%) injury. In terms of repair; the mortality rate was highest for ligation (6/10, 60%) followed by autologous venous and synthetic graft repair (2/6, 33.3% each). The univariate analysis revealed nine variables invariably associated with higher mortality (table III).

On multivariate analysis of these variables; mechanism of injury [OR 1.11 (95% CI: 1.03-1.38), P = 0.002], systolic BP [OR 1.11 (95% CI: 1.02-1.33), P = 0.002], serum lactate levels [OR 1.29 (95% CI: 1.09-1.44), P = 0.002], concomitant solid organ injury [OR 1.05 (95% CI: 1.01-1.35), P = 0.002], concomitant extra abdominal injuries, PRCT [OR 1.21 (95% CI: 1.11-1.67), P = 0.037] and ICU stay [OR 1.09 (95% CI: 1.02-1.44), P = 0.003]; were found to be independent positive predictors of higher mortality.

#### **DISCUSSION:**

Abdominal IVC Injuries are rare and the overall incidence ranges from 0.5 to 5% for penetrating and 0.6–1% of blunt trauma.<sup>8</sup> Injuries following penetrating trauma are more common.<sup>8, 9</sup> In our study 66.7% injuries were due to penetrating trauma with 28.5% caused by shrapnel from a bomb blast and 23.8% by gunshot. Although penetrating injuries are associated with damage to many surrounding structures, they were associated with far lower mortality rates when compared with their blunt counterparts.<sup>1,9</sup> Van Rooyen et al reported mortality rate of 37% for penetrating as compared to 90% for blunt trauma.<sup>10</sup> Our study showed similar results with a mortality of 35.7% for penetrating injuries as compared to 57.1% (8/14) for the blunt injuries.

In terms of site, infra renal segment (55-85%) is most commonly damaged while supra hepatic injuries (2-11%) are least commonly injured sites.<sup>8-10</sup> Likewise in our study, 76.2% of the injuries affected the infra renal segment when compared to 14.3% supra hepatic injuries. However it is worth noting that the segment which is damaged mostly has lowest mortality.<sup>1,10</sup> Van Rooyen et al reported mortality rates of 33%, 22% and 100% respectively for infra renal, supra renal and retro hepatic injuries.<sup>10</sup> Likewise, in our study, the mortality rates for infra renal, supra renal and supra hepatic were 50%, 75% and 100% respectively.

Repair of IVC injuries may be divided into two main groups, open and endovascular. Open repair include

Table III: Univariate Analysis of Variables

Patient Variables	Survival Group	Expired Group	Univariate Analysis ORs (95% CI)	P Value
Total patients (n)	24	18		
Mean Age (Years $\pm$ SD)	23.2 $\pm$ 8.3	24.1 $\pm$ 9.2	1.42 (0.59-4.32)	0.241
Gender Male [n, (%)]	9 (75)	7 (77.8)	1.84 (0.44-9.82)	0.384
Gender Female [n, (%)]	3 (25)	2 (22.2)	1.72 (0.31-3.42)	0.447
<b>Mechanism of Injury:</b>			0.15 (0.11-1.44)	<b>0.194</b>
Blunt [n, (%)]	6 (25)	8 (44.4)		
Penetrating [n, (%)]	18 (75)	10 (55.6)		
<b>Vital Signs at Presentation:</b>				
Pulse Rate per minute (Mean $\pm$ SD)	100 $\pm$ 25	105 $\pm$ 20	1.32 (1.11-1.69)	0.399
Systolic Blood Pressure (mmHg $\pm$ SD)	109 $\pm$ 15	98 $\pm$ 10	1.12 (1.01-1.24)	<b>0.184</b>
Diastolic Blood Pressure (mmHg $\pm$ SD)	74 $\pm$ 10	65 $\pm$ 7	1.01 (0.76-1.02)	<b>0.191</b>
Respiratory Rate (Mean $\pm$ SD)	20 $\pm$ 4	22 $\pm$ 3	0.94 (0.82-1.32)	0.245
Oxygen Saturation (% $\pm$ SD)	92 $\pm$ 3	93 $\pm$ 4	1.06 (0.92-1.67)	0.311
<b>Operative Variables:</b>				
Primary Repair [n, (%)]	12 (50)	2 (16.7)	1.01 (0.54 -1.98)	0.319
Vein ligation [n, (%)]	4 (16.7)	6 (50)	0.82 (0.19-2.19)	0.599
Vein Graft [n, (%)]	4 (16.7)	2 (16.7)	1.66 (0.52-1.53)	0.377
Dacron / Polyester Graft [n, (%)]	4 (16.7)	2 (16.7)	1.66 (0.52-1.53)	0.377
Associated solid organ injury [n, (%)]	12 (50)	16 (88.9)	1.0 (0.66-1.31)	<b>0.139</b>
Associated extra-abdominal injury [n, (%)]	10 (41.7)	18 (100)	1.43 (0.25-2.66)	<b>0.112</b>
Temporary Intravascular Shunt [n, (%)]	0 (0)	4 (22.2)	0.98 (- 4.99)	1.000
<b>Other Variables:</b>				
Injury Severity Score (Mean $\pm$ SD)	17.4 $\pm$ 10.2	19.5 $\pm$ 7.6	1.01 (0.74-1.22)	0.491
Revised Trauma Score (Mean $\pm$ SD)	5.8 $\pm$ 0.88	6.2 $\pm$ 0.69	0.99 (0.81-1.27)	0.389
Serum Lactate (mmol/L $\pm$ SD)	3.2 $\pm$ 2.1	6.5 $\pm$ 3.6	1.24 (1.09-2.01)	<b>0.166</b>
Packed Red Cell Units (Mean $\pm$ SD)	6.4 $\pm$ 4.2	9 $\pm$ 2.4	1.03 (0.71-1.28)	<b>0.171</b>
Total Hospital Stay in days (Mean $\pm$ SD)	12.4 $\pm$ 8.6	21.4 $\pm$ 6.4	1.66 (0.27-1.88)	<b>0.187</b>
Total ICU Stay in days (Mean $\pm$ SD)	9.1 $\pm$ 7.2	16.2 $\pm$ 3.6	1.04 (1.03-1.22)	<b>0.141</b>

primary venorrhaphy, placement of grafts and ligation.<sup>10-13</sup> The grafts may be autologous venous or synthetic such as Dacron or polyester.<sup>14</sup> When less than 50% of the vessel circumference has been compromised and a transverse closure is possible primary venorrhaphy is a favourable option.<sup>6, 14</sup> When the injury extends beyond the 50% mark, graft placement is the intervention of choice since repair would result in pronounced narrowing of vessel diameter and incur the risk of eventual stenosis and thrombosis.<sup>6</sup> Prosthetic grafts are

preferred due to less time to repair despite increased risk of infection.<sup>14</sup> One study documented the use of primary venorrhaphy in 14 patients with no mortality, however synthetic graft repair was carried out in a single patient who later died.<sup>10</sup> In contrast, Rosengart et al demonstrated 44% mortality rate for primary repair and the lone patient in whom synthetic graft was used, survived.<sup>1</sup> An assessment of our data revealed that 85.7% patients undergoing primary repair survived, while survival rates for both venous and synthetic grafts were 66.6% each.

Ligation of IVC is associated with a high mortality ranging from 41-66%.<sup>1,10</sup> Despite the unfalteringly high mortality rates associated with IVC ligation, it remains a therapeutic option for, and is often life-saving in, the critically wounded patients.<sup>15</sup> In our study, 27.8% patients underwent ligation as a last ditch resort with a mortality rate of 60%. All of these patients had bilateral fasciotomies and 83.3% developed DVT.

Various studies have looked into different parameters as predictors of increased mortality. Hampton et al concluded that increased PRCT was associated with higher mortality ( $P = 0.001$ ).<sup>16</sup> Our multivariate analysis also pointed out PRCT as a positive predictor for higher mortality ( $P=0.037$ ). Similarly high serum lactate levels are also associated with higher mortality.<sup>1,17</sup> Rosengart et al found that lactate levels of 4.0 mmol/L or higher was associated with high (59%) mortality.<sup>1</sup> Similarly, Hampton et al also reported adverse outcome ( $P=0.007$ ) with serum lactate levels greater than or equal to 2.5 mmol/L.<sup>16</sup> Our multivariate analysis showed statistically significant difference in terms of mortality in patients with higher serum lactate levels ( $P=0.002$ ). Another factor which was found significant in our study was systolic BP at the time of presentation. Similar results have been reported by other studies.<sup>1,11,13,17</sup> Rosengart et al concluded that patients presenting with systolic BP of less than 80mmHg had an alarmingly high mortality (76%) in contrast with the hemodynamically stable group (30%).<sup>1</sup> Similarly Maciel et al stated that 50% of all non survivors presented with hypotension and 77% of all survivors were hemodynamically stable ( $P=0.03$ ).<sup>13</sup> Navsaria et al also documented that 93.3% of non survivors in their study presented with shock.<sup>17</sup> ICU stay though significant in our study, has not yielded noteworthy outcomes in previous studies. On the other hand, in past studies detail significant influence imparted by other factors such as Injury Severity Score,<sup>11</sup> which although studied, was found to be insignificant in our study.

### CONCLUSIONS:

Management of IVC injuries is complex. Blunt trauma to abdomen and injury to the supra hepatic segment are associated with highest mortality. Ligation should be used as a last resort in exsanguinating cases. Preoperative high serum lactate levels and hypotension at time of presentation are independent positive predictors for higher mortality.

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- Received for publication: 19-07-2019  
Accepted after revision: 30-09-2019
- Author's Contributions:  
Rashid Usman: Study conception, data collection, writing, critical review, final approval and accountability of all aspects.  
Muhammad Jamil: Data collection, data analysis, investigations, critical review, final approval and accountability of all aspects  
Saira Ambreen: Writing, critical review, final approval and accountability of all aspects.  
Raoon Khan: Writing, critical review, final approval and accountability of all aspects.  
Shahid Majeed: Critical review, final approval and accountability of all aspects.
- Conflict of Interest:  
The authors declare that they have no conflict of interest.
- Source of Funding:  
None
- How to cite this article:  
Usman R, Jamil M, Ambreen S, Khan R, Majeed S. Management of traumatic abdominal inferior vena cava injuries and predictors of its mortality. *J Surg Pakistan.* 2019;24(3):110-15. Doi:10.21699/jsp.24.3.2.