

# Postmortem CT scan in intoxication cases: A necessity or just an indulgence

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## Abstract

**Introduction:** The aim of this study is to correlate urinary bladder distension and pulmonary edema on postmortem computed tomography (CT) scans with toxicology results in postmortem cases. **Methods and Results:** The study population was the postmortem cases of Asian population ranging from 16 to 75 years old in which blood and/or urine samples sent for alcohol and/or drug of abuse (DoA) analysis in year 2016 at our centre. Out of 434 cases, 54 from each group of positive and negative alcohol and/or DoA. Postmortem findings of lungs and postmortem CT scan urinary bladder volume (UBV) were recorded. Statistical significant correlation was obtained between urinary bladder distension on postmortem CT scan and cases with positive alcohol detection. However, the sensitivity was relatively low at 51.7%, whereas the specificity was 75% at the cut-off point. Low sensitivity and specificity at around 52.7% were obtained for pulmonary edema related to alcohol/DoA. This showed that UBV alone or pulmonary edema alone was not really a good indicator for alcohol or DoA intoxication. However, combination of both indicators provided higher sensitivity (73.3%) although specificity was lowered to 53.8%. **Conclusion:** The findings of postmortem CT scan bladder distension and pulmonary edema could possibly identify intoxication cases but not conclusive.

**Key words:** Postmortem computed tomography; pulmonary edema; toxicology-related deaths; urinary bladder distension

## Introduction

Computed tomography (CT) and magnetic resonance (MR) imaging are gaining acceptance to use in routine forensic investigations but still remain challenging in the detection of non-traumatic causes of death. The use of postmortem CT (PMCT) scan in cases of intoxication death is still debated on its significance especially when only limited postmortem required.

Intoxication is a state in which a person's normal capacity to act or reason is inhibited by alcohol or drugs.<sup>[1]</sup> The level of intoxication varies in different individuals. Many factors influence the effect of intoxication such as gender, tolerance, and the condition of internal organs especially liver.<sup>[2]</sup> Thus, there is no definite level which can cause the same effect of intoxication in different individuals. Approximately one-third of all cases brought to our institute

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for medico-legal investigation, test positive for alcohol, narcotics, and/or pharmaceutical drugs.

Apart from hyperdense residues from tablets on the PMCT scan which could indicate possible intoxication, urinary bladder distension and pulmonary edema has also been relatively linked with toxicology-related death.<sup>[3,4]</sup> Moreover, other common findings in intoxication-related deaths are aspiration (66%), cerebral edema (49%), pulmonary emphysema (38%), and fatty liver disease (36%).<sup>[5]</sup>

The purpose of this study is to identify the bladder distension and pulmonary edema on PMCT scan and relate to the cases of intoxication. This study will also determine the usefulness of PMCT scan in limited postmortem examination of suspected intoxication cases.

## Methodology

This was a retrospective cross-sectional study of postmortem cases in which blood and/or urine samples were sent for alcohol and/or drugs of abuse (DoA) analysis in the year 2016 at our centre. The inclusion criteria were the postmortem cases ranging from 16 to 75 years old with confirmed alcohol and/or DoA results. Decomposed cases and cases with ruptured urinary bladder were excluded.

DoA included in our study were amphetamine type stimulants, cocaine, cannabis and opiates. Any level of alcohol and DoA detected in the blood or urine were taken as positive samples. Based on the inclusion criteria, the confirmed results of alcohol and/or DoA were retrieved from the postmortem reports.

UBV was calculated using bladder diameter measurements consistent with the methods used by Rohner *et al.*<sup>[6]</sup> in their study. The maximal left-right diameter ("a") on the original axial images, maximal crano-caudal ("b") and anterior-posterior diameter ("c") on multiplanar reformatted (MPR) sagittal images were measured using OsiriX software on the PMCT terminal. UBV was then calculated based on the equation used in ultrasonographic volumetry,  $V = a \times b \times c \times 0.5$  [Figure 1].<sup>[7]</sup> Sensitivity and specificity were analyzed by receiver operating characteristic (ROC) curve analysis.

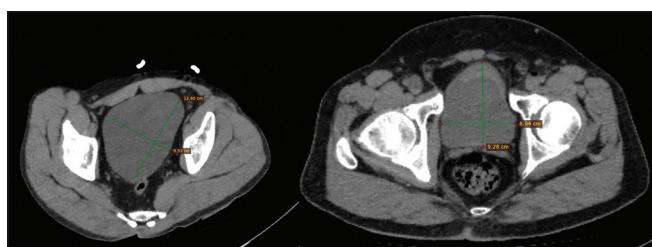


Figure 1: Measurement of the parameters

The criteria for pulmonary oedema (PO) were weight of more than 500 g for each lung and postmortem demonstration of edema which corroborated with histology of the lungs. PO findings were retrieved from the PMCT scans and verified from postmortem reports.

There was a total of 434 postmortem cases at our centre ranging from 16 to 75 years old with blood and/or urine samples sent for toxicology analysis to the Chemistry Department in 2016. The study population was further categorized into positive (327 cases) and negative (107 cases) toxicology results and subsequently underwent randomized sampling by algorithm sequence to avoid biased results. Fifty-four samples from each population were selected and analyzed. The study population was then grouped into four main categories: (i) both negative PO and UBV; (ii) positive PO only; (iii) positive UBV; and (iv) both positive PO and UBV. The positive UBV was based on Rohner *et al.* and our cut-off value. We calculated our cut-off values based on the optimum sensitivity and specificity obtained for positive UBV to reflect those individuals presented with positive alcohol and/or DoA. Chi-square and Spearman Correlation tests were used to correlate these four groups. Kruskal-Wallis test was subsequently used to assess the significance levels ( $p$ ) between each group and within each group.

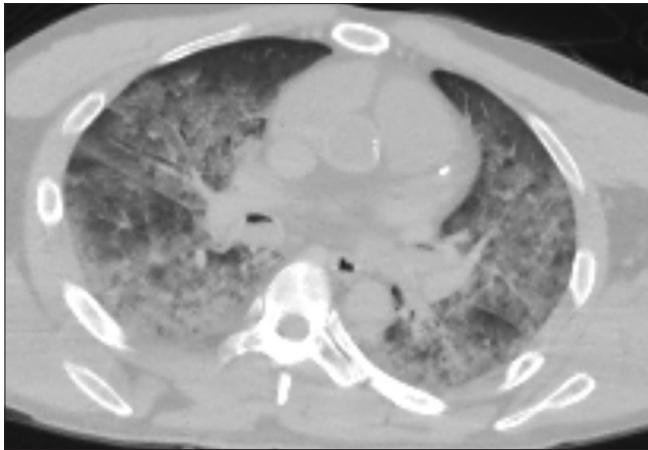
## Results

A total of 108 cases were categorized in either group of positive alcohol, positive DoA, positive for both alcohol and DoA or negative for both alcohol and DoA results selected in this study. The reason for random selection was to standardize the population in each group in order to avoid bias results. We did not specify the level for blood/urine alcohol or DoA, as this study is to relate the significance of bladder distension and PO and intoxication. Therefore, we also need to include the lower levels as well to calculate the relatedness. The lowest level for blood alcohol and urine alcohol were 35 and 44 mg/dl, respectively.

From the total of 108 cases selected, the average age of the selected cases was  $40.2 \pm 13.1$  years old and 98% were males with only 2% being females. In terms of nationality, local (75%) were the majority followed by Myanmar and Nepal.

PO detected on the PMCT scan [Figure 2] is distinguished from hypostasis based on the location of edema and sharper margins. Hypostasis has sharper margins compared to PO on PMCT.<sup>[8,9]</sup> Furthermore, we also verified the PO with postmortem findings and histology.

The calculated UBV ranged from 17.38 to 704.73 ml with an average of  $187.36 \pm 139.87$  ml [Table 1]. Sensitivity and specificity were analyzed using ROC curve and areas



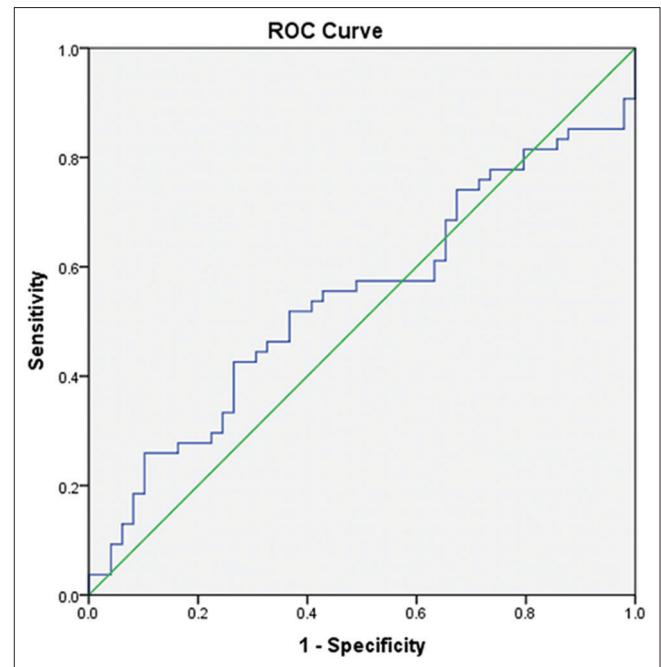
**Figure 2:** PO on PMCT scan

measured under the ROC curve were 0.546 as shown in Figure 3. Based on Rohner *et al.*'s cut-off point, the sensitivity and specificity obtained for 182 ml was 29.6% and 75.5%. For 330 ml, the sensitivity and specificity obtained were 11.1% and 93.9%, respectively.

From our study, the cut-off value of UBV to indicate urinary bladder distension was 149.41 ml based on optimum sensitivity (42.6%) and specificity (73.5%). As such, we have also categorized the selected cases into positive ( $>149$  ml) and negative ( $<149$  ml) urinary bladder distension. The study population was also separated into four main groups: both negative PO and UBV (32 cases); only positive PO (40 cases); only positive UBV (21 cases); and both positive PO and UBV (15 cases).

Chi-square and Spearman Correlation tests were conducted to correlate PO with alcohol/DoA. There was neither statistical correlation nor significant difference between the categories obtained [Table 2]. The sensitivity and specificity were interpreted as relatively low at around 52.7%. Chi-square and Spearman Correlation tests were subsequently conducted to correlate urinary bladder distension on PMCT with alcohol/DoA. There was also neither statistical correlation nor significant difference between the categories as shown in Table 3. The sensitivity and specificity were 63.9% and 53.7%, respectively. In addition, we have also conducted statistical tests separately for blood DoA, blood alcohol, urine DoA, and urine alcohol. We obtained a statistical difference between urine alcohol and bladder distension. This was represented as  $\chi^2$  ( $1, N = 57$ ) = 4.293,  $P < 0.05$  and also showed positive correlation statistically at a lower strength with  $r = 0.274$ ,  $P < 0.05$  [Tables 4 and 5]. PO however did not show a statistical difference between the separate groups of alcohol and DoA.

Further, Chi-square and Spearman Correlation tests were also conducted to correlate both PMCT urinary bladder distension and PO with alcohol/DoA. There was



**Figure 3:** ROC curve analysis between urinary bladder distension with alcohol and/or DoA results

**Table 1: Descriptive statistics of parameters**

Parameters	Minimum	Maximum	Mean	Std deviation
A (AUBD), cm	3.98	10.74	7.51	1.65
B, cm	2.94	14.93	6.93	2.24
C, cm	2.61	10.38	6.34	1.82
UBV, ml	17.38	704.73	187.36	139.87
BAC, mg/100 ml	0.0	246.0	47.02	76.43
UAC, mg/100 ml	0.0	750.0	84.18	143.16

**Table 2: Categories of PO according to alcohol/DoA detection**

Pulmonary Edema	Negative Alcohol/DoA	Positive Alcohol/DoA	Total
No Edema (Left and Right Lung)	28	25	53
Edema (Left and Right Lung)	26	29	55
Total	54	54	108

**Table 3: Categories of urinary bladder distension according to alcohol/DoA detection**

Urinary Bladder Distension	Negative Alcohol/DoA	Positive Alcohol/DoA	Total
No Bladder Distension	41	31	72
Bladder Distension	13	23	36
Total	54	54	108

a significant correlation between combined PO and UBV with categories of negative and positive alcohol detection or DoA, represented as  $r = 0.280$ ,  $P < 0.05$ . There was higher sensitivity (73.3%) and lower specificity (53.8%) in

**Table 4: Categories of urinary bladder distension according to urine alcohol detection**

Urinary Bladder Distension	Negative Urine Alcohol	Positive Urine Alcohol	Total
No Bladder Distension	21	7	28
Bladder Distension	14	15	29
Total	35	22	57

**Table 5: Symmetric measures between urine alcohol detection and UBV at cut-off 149.41 ml**

	Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Interval by Interval	Pearson's R	0.274	0.126	2.117
Ordinal by Ordinal	Spearman Correlation	0.274	0.126	2.117
No. of Valid Cases	57			0.039 <sup>c</sup>

<sup>a</sup>Not assuming the null hypothesis. <sup>b</sup>Using the asymptotic standard error assuming he null hypothesis. <sup>c</sup>Based on normal approximation

**Table 6: Categories of both indicators (PO and UBV) according to alcohol/DoA detection**

Pulmonary Edema and Urinary Bladder Distension	Negative Alcohol/DoA	Positive Alcohol/DoA	Total
Negative PO and UBV	19	13	32
Positive PO or UBV	31	30	61
Positive PO and UBV	4	11	15
Total	54	54	108

the detection of alcohol/DoA when both indicators were combined, that is, positive PO and UBV [Table 6].

## Discussion

The accuracy of radiologically calculated UBV studied by Rohner *et al.*<sup>[6]</sup> They proved that autopsically measured UBV and radiologically measured UBV were same. They also attempted to correlate urinary bladder distension and intoxication. They also showed that positive toxicology results strongly correlated with increasing UBV ( $P < 0.001$ ). UBV of 182 and  $>330$  ml indicated positive toxicology results with a sensitivity/specificity of 40%/87% and 25%/97%, respectively.

We concur with the findings by Rohner *et al.* that it is not possible to identify intoxication based on the postmortem volume of urinary bladder alone. The only statistically significant correlation between urinary bladder distension on PMCT was with cases of positive alcohol detection. However, the sensitivity was relatively low at 51.7% while the specificity was 75% at the cut-off point of 149.41 ml. Hence, it is important to note that intoxication may also be present in cases with low UBV. These findings concur with Uchigasaki *et al.*<sup>[4]</sup> One of the reasons mentioned in their study was the bladder evacuation due to intoxication-induced seizures.

Similarly PO alone could not indicate the presence of alcohol/DoA. This was reflected from the low sensitivity and specificity around 52.7% for PO in relation to positive

alcohol/toxicology. Hence, both indicators should be combined during the interpretation for the possibility of intoxication. We obtained higher sensitivity (73.3%) although specificity was lowered to an acceptable level (53.8%) when both indicators combined. These indicators can raise the suspicion of intoxication.

The findings of bladder distension and PO could be helpful in cases where limited autopsy is required. Limited autopsy in this context would be an external examination and body fluids sampling without evisceration or organ dissection. But this must be carefully verified with the clinical history or background information and also excluding suspicious circumstances. Otherwise, a complete postmortem examination is warranted.

Nevertheless, there were some limitations to our study. The quantity of substances that were detected by toxicological analysis influenced by complex interactions such as individual metabolic rates, increased tolerance to a substance, time interval since ingestion, length of the agony and postmortem interval. Moreover, our findings could not be used to determine intoxication in decomposed or skeletal remain cases.

## Conclusion

The significant distension of urinary bladder and PO detected on PMCT scans coupled with detailed clinical history should raise suspicion of intoxication. This is particularly useful in cases of where limited postmortem examination is required. However, it must be remembered that full autopsy is still warranted whenever there is a doubt. Future studies should include more indicators of intoxication on PMCT such as cerebral edema and fatty liver.

## Ethical statement

I testify on behalf of all co-authors that our article submitted to *Indian Journal of Radiology and Imaging*.

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Nil.

**Conflicts of interest**

There are no conflicts of interest.

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