Sensitivity and specificity of CT scanning for determining the number of internally concealed packages in ‘body-packers’

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ABSTRACT

Introduction If package counts on abdominal CTs of body-packers were known to be accurate, follow-up CTs could be avoided. The objective was to determine the accuracy of CT for the number of concealed packages in body-packers, and the reliability of package counts reported by body-packers who admit to concealing drugs.

Methods Suspected body-packers were identified from the emergency departments (ED) database. The medical record and radiology reports were reviewed for package counts determined by CT, patient-reported and physically retrieved. The last method was used as the reference standard. Sensitivity, specificity, positive predictive values (PPV) and negative predictive values (NPV) were calculated for CT package count accuracy. Reliability of patient-reported package counts was assessed using Pearson’s correlation coefficient.

Results There were 50 confirmed body-packers on whom 104 CT scans were performed. Data for the index and reference tests were available for 84 scans. The sensitivity, specificity, PPV and NPV for CT package count were 63% (95% CI 46% to 77%), 82% (95% CI 67% to 92%), 76% (95% CI 58% to 89%) and 71% (95% CI 56% to 83%) respectively. For CTs with a package count <15, the sensitivity, specificity, PPV and NPV for CT package count were 96% (95% CI 80% to 99%), 95% (95% CI 82% to 99%), 93% (95% CI 76% to 99%) and 97% (95% CI 86% to 100%), respectively. Correlation between patient-reported package counts and the number of packages retrieved was high (r=0.90, p<0.001, R²=81%).

Conclusions The accuracy of CT for determining the number of concealed packages is poor, although when applied to patients with few concealed packages accuracy is high and is useful as a rule-out test. Among patients who have admitted to drug concealment, the number of packages reported to be concealed is reliable.

INTRODUCTION

Illicit drugs are smuggled through international airports by so-called body-packers or drug-mules. Body-packers attempt to conceal drugs within their body while passing through airport security by wrapping drugs in layers of plastic, latex and wax, and then ingesting these packages or inserting them into the rectum or vagina. International travellers suspected of drug concealment may be brought to emergency departments (ED) for imaging. The procedure at this hospital is to perform a non-contrast CT abdomen in all such presentations unless the person is pregnant or they refuse consent. For those cases where the CT is positive, a count of the number of packages is made, and the person is kept in hospital until these packages have been passed in the stool or retrieved from other orifices. A repeat CT is then performed to confirm that no packages remain due to concerns that the package count may be inaccurate, especially when they number in the hundreds. It is important that no concealed drugs remain in the person once they are discharged because packages can rupture, releasing lethal doses of drug into the body,1–4 while packages not retrieved in the hospital may be passed later in jail, allowing the distribution of illicit drugs among the prison population.

Body-packers tend to be a young population, and the radiation exposure of two abdominal CT scans at this institution has been estimated to be 14.1 mSv.5 There are concerns that this radiation may carry long-term risks of malignancy,6–8 with the risk of cancer estimated between 1 in 1000 to 1 in 10 000 for an exposure at this level.9 It would be possible to avoid this second CT if package counts were known to be accurate. Similarly, serial CT scans could be avoided when offenders admit to concealing drugs internally if the number reported by offenders was known to be reliable. These patients could be observed until all reported packages had been passed, and a single CT...
performed at the end to confirm the absence of packages. Previous research has focused on the accuracy of abdominal CT in determining the presence or absence of any concealed packages; however, there is minimal literature on the accuracy of the CT for determining the number of packages concealed internally among confirmed body-packers. There was a case report of CT missing a single concealed package; in a study using a phantom model to simulate a body with concealed packages, the sensitivity was 96% and specificity 100%; in a simulated pig model, the sensitivity and specificity were both 100%. The aim of this study was to determine the accuracy of the abdominal CT scan for determining the number of internally concealed packages in body-packers. Secondary aims were to determine the reliability of package counts reported by offenders who have admitted to concealing drugs and to provide descriptive clinical information regarding body-packers brought to the ED.

METHODS
Study design and setting
This retrospective cross-sectional analytical study was conducted in the ED of a tertiary referral centre located in Sydney, Australia, over the period from October 2008 to September 2013. This period was chosen because the introduction of a new ED computer management system allowed accurate and consistent retrospective identification of the study population. Permission for the study was granted by the South Eastern Sydney Local Health District (Northern Sector) Human Research Ethics Committee.

Selection of participants
All patients brought to the hospital by police during the study period who were confirmed by CT or physical evidence to be concealing packages internally were included and had a chart review performed. Patients were identified from the ED database. Patients whose mode of arrival was recorded as ‘police/correctional services’ were first identified, and from this group the triage description of the presenting problem was viewed from which people under suspicion of drug concealment can be easily identified. The radiology database was then accessed for the reports of CT scans to identify those suspects confirmed to have concealed packages. Where the CT was negative for concealed packages or no CT was done, the discharge summary was reviewed for documentation of physical evidence of concealment.

Methods and measurements
The index test was the number of internally concealed packages recorded on the CT report. This was determined for all scans performed during the admission. These scans were reported by generalist radiologists. All imaging was performed using the Toshiba Aquilion 64-slice CT scanner. Where the radiology report did not contain an unequivocal statement of the exact package count, these scans were re-reported by a senior radiology registrar blinded to all clinical information other than that provided on the original request form. This study was intended to be a pragmatic study reflecting the accuracy likely to be achieved in standard clinical practice where CT scans are reported once by a generalist radiologist and after-hours ED physicians must act upon reports provided by radiology registrars.

The reference standard was the number of packages collected following each CT, determined by medical chart review. Due to the forensic importance, this information was generally well recorded in detail in the medical notes. A standardised template for data extraction was created and refined through several trials on a small sample of medical records. Each data point was defined, and the section of the medical record where it was to be obtained specified. Data collected were patient demographics; the number of packages retrieved after each CT; the number of concealed packages reported by those offenders who admitted to drug concealment; time between the CT demonstrating no remaining packages and discharge of the patient; method of package removal; sites of...
concealment; and clinical evidence of drug toxicity or other complication.

The primary outcome was the accuracy of the CT for determining the number of concealed packages. The secondary outcome was the reliability of patient-reported package counts in those who admitted to drug concealment.

Analysis
The sensitivity, specificity, positive predicted value (PPV) and negative predictive value (NPV) of the CT for counting concealed packages were calculated. When the CT count was greater than the reference standard, this was considered a false-positive scan. When the CT count was less than the reference standard, this was considered a false-negative scan. When the CT count equalled the reference standard, this was considered a true-positive scan. CTs were also done to confirm the absence of packages. Where the CT was interpreted as negative but further packages were passed, this was considered a false-negative scan; when no further packages were passed, this was considered a true negative scan. With this method of reporting diagnostic accuracy, it was not possible to appreciate the magnitude of error in the CT counts of packages. To allow for this interpretation, the data were further analysed using Bland–Altman bias plot techniques.

To determine the reliability of patient-reported package counts, the data were presented as a scatter plot of patient-reported package counts versus package counts determined by the reference standard, and the relationship quantified using Pearson’s correlation coefficient. Simple linear regression was used to obtain R², which is interpreted as the proportion of total variation that can be accounted for by the linear relationship between the two variables. This analysis was conducted using IBM SPSS statistics V.21 (IBM Corp, Armonk, New York, USA) and MedCalc V.12.7.0 (MedCalc Software, Ostend, Belgium).

RESULTS
During the study period, 228 suspected body-packers were brought to the ED, of whom 50 were confirmed to be concealing drugs. A total of 104 CT scans were performed on these confirmed cases with a mean of two scans per patient (SD 1; range 0–4). Two patients had no scans: one was pregnant, the other exceeded the weight capacity of the CT gantry. The number of packages collected could not be determined from the medical record due to poor documentation in 18 cases, and a package count could not be determined from the CT for two scans, leaving 84 scans available for the primary analysis.

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Table 1  Baseline characteristics of confirmed body-packers

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n (body-packer cases)</td>
<td>50</td>
</tr>
<tr>
<td>Study duration (months)</td>
<td>60</td>
</tr>
<tr>
<td>n (CT scans)</td>
<td>104</td>
</tr>
<tr>
<td>Number of CTs mean (SD)</td>
<td>2 (1) (range 0–4)</td>
</tr>
<tr>
<td>Packages concealed median</td>
<td>51 (IQR 5–86, range 1–187)</td>
</tr>
<tr>
<td>Hospital LOS (days)</td>
<td>1.9 (IQR 1.0–3.0)</td>
</tr>
<tr>
<td>Time: last CT to discharge (hours)</td>
<td>2.6 (IQR 1.4–5.4)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>38 (IQR 30–44)</td>
</tr>
<tr>
<td>Male</td>
<td>34 (68%)</td>
</tr>
<tr>
<td>Sites of concealment</td>
<td></td>
</tr>
<tr>
<td>Gastrointestinal tract</td>
<td>50 (100%)</td>
</tr>
<tr>
<td>Vagina</td>
<td>7 (14%)</td>
</tr>
<tr>
<td>Foreskin</td>
<td>1* (2%)</td>
</tr>
<tr>
<td>External to body</td>
<td>3 (6%)</td>
</tr>
<tr>
<td>Method of expulsion</td>
<td></td>
</tr>
<tr>
<td>Per rectal expulsion (no laxative)</td>
<td>3 (6%)</td>
</tr>
<tr>
<td>Per rectal expulsion with laxative</td>
<td>45 (90%)</td>
</tr>
<tr>
<td>Manual retrieval from orifice</td>
<td>7 (14%)</td>
</tr>
<tr>
<td>Endoscopic retrieval</td>
<td>2† (4%)</td>
</tr>
<tr>
<td>Surgical removal</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Complications‡</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

*Unconfirmed, possible concealed foreign body noted on review of CT after discharge.
†Endoscopic retrieval failed and packages ultimately passed per rectum.
‡Complications considered were package rupture, drug toxicity, bowel obstruction or perforation.


Figure 2  Three-dimensional reconstruction of a non-contrast CT scan demonstrating the non-discrete appearance of multiple packages in close approximation, rendering a precise package count impossible.
bowel obstruction or perforation. Two patients with a package persisting in the stomach had endoscopic retrieval attempted, but in both cases the package had progressed beyond the duodenum by the time of the procedure and the package ultimately passed uneventfully.

The sensitivity, specificity, PPV and NPV of the CT are presented in table 2. The magnitude of the discrepancy between CT-determined package counts and packages retrieved is presented in figure 3. There was perfect agreement with the reference standard in 73% of all CT scans, but this was entirely accounted for by scans with package counts <15. We conducted a posthoc analysis of diagnostic accuracy for this subgroup, which is presented in table 2. There were no instances of packages being passed after a negative CT.

Of the 50 confirmed body-packers, 33 (66%) admitted to concealing drugs. Three did not indicate how many were concealed, three did not have the reference standard and one had neither the reference standard nor indicated how many were concealed. This left 24 cases available for analysis. A scatter plot of patient-reported package count versus package counts determined by the reference standard is presented in figure 4. The correlation coefficient for this relationship was 0.90 (p<0.001), $R^2=81\%$.

### DISCUSSION

Due to the forensic and clinical implications of missing concealed drugs, the accuracy of the package count on the first CT scan would need to be very high to avoid performing a second CT to confirm the absence of concealed drugs. Our results indicate that the accuracy of the CT for counting packages is poor, and a second CT is necessary. It could be argued that the second CT should not be done because the poor accuracy would render it unable to exclude the presence of packages; however, our results suggest that accuracy improves with low package counts and performs particularly well as a rule-out test given there were no instances of a package being passed after a negative scan. This is consistent with other research that has shown the CT scan to have a high negative predictive value when used simply to determine the presence or absence of any packages.\[12\text{--}14\]

We recommend future research in this area should focus on confirming the accuracy of the CT scan for low-package counts in a prospective study.

There has been minimal research done on the accuracy of the CT scan for determining the number of concealed packages. The information that is available is from phantom models\[16\] or pigs.\[17\] Our research constitutes the first evaluation in a clinical setting and indicates that the true accuracy is far lower than was found in these simulated models.

This study provides evidence for other strategies to reduce CT usage. More than half of the offenders admitted to drug concealment, and the number of packages reported correlated closely to the number of packages collected. For such cases, it would be unnecessary to perform an initial CT. Instead, we recommend that the patient be given laxatives and observed until the number of packages passed approximates the number reported, then wait for several bowel motions clear of any packages before performing a single CT to rule out further concealed packages. Where the initial CT demonstrated a large number of packages, we noted several patients having two or three ‘check’ CTs. A similar observation strategy should also be applied for these cases to avoid a premature follow-up CT. To help inform how many bowel motions clear of packages should be observed before doing a CT, future research should take note of the number of clear bowel motions that reliably indicates complete passage of all packages.

### Table 2  Diagnostic accuracy for the detection of concealed packages

<table>
<thead>
<tr>
<th></th>
<th>All CT scans (n=84)</th>
<th>CT scans&lt;15 packages concealed (n=64)</th>
</tr>
</thead>
<tbody>
<tr>
<td>True positive</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>False positive</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>False negative</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>True negative</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>Sensitivity % (95% CI)</td>
<td>63 (46 to 77)</td>
<td>96 (80 to 99)</td>
</tr>
<tr>
<td>Specificity % (95% CI)</td>
<td>82 (67 to 92)</td>
<td>95 (82 to 99)</td>
</tr>
<tr>
<td>PPV % (95% CI)</td>
<td>76 (58 to 89)</td>
<td>93 (76 to 99)</td>
</tr>
<tr>
<td>NPV % (95% CI)</td>
<td>71 (56 to 83)</td>
<td>97 (86 to 100)</td>
</tr>
</tbody>
</table>

NPV, negative predictive value; PPV, positive predictive value.

### Figure 3  Bland–Altman bias plot for the agreement between package counts determined by CT and the reference standard. (—) Identity/zero difference; (—) bias/mean difference; (—) 95% limits of agreement (−28.5 to 23.0).

### Figure 4  Scatter plot of the number of packages reported by the patient to be concealed versus the number of packages retrieved.
Previous researchers have suggested that body-packers should be managed in monitored settings in case of package rupture,\textsuperscript{16–17} although case series have indicated this risk is low (1–5%).\textsuperscript{20–22} Our study would indicate this is unnecessary for stable patients as there were no cases of package rupture, drug toxicity or other complication over the 5-year study period, which may reflect improved care with package construction since these series were published.

**Limitations**

This study has some limitations that should be considered when interpreting the results. Data were collected retrospectively from the medical record, and the reliability of these data is dependent on the accuracy of the information recorded in the medical record. This is most relevant for the reliability of the reference standard. Those performing the chart review were not blinded to the study objective or the CT result. This knowledge may influence the interpretation of equivocal data in the medical record.

Twenty scans could not be included due to missing data for the reference or index test. If the test characteristics of these excluded cases differed systematically from the included cases, this could potentially bias the results. However, as the majority were due to poor documentation, this is likely to be a random event and unlikely to have affected the estimates of the test characteristics.

The reference standard was potentially affected by measurement bias as the time between the CT that demonstrated no remaining packages and discharge into police custody was short. Therefore, the reference standard may not be robust with respect to false-negative scans. However, previous research has demonstrated the CT scan to be reliable as a rule-out test, suggesting that this bias would have been minimal.\textsuperscript{12–14} The calculation of specificity was likely affected by selection bias. We did not include patients who were determined not to be body-packers based on a negative CT. This was because these participants were discharged rapidly from the ED with no opportunity for stool observation, and hence no reliable reference standard. We observed no instances of a package being passed after a negative CT scan among study participants, so it is probable that most of these excluded cases were true negatives.

**CONCLUSION**

The overall accuracy of CT for determining the number of concealed packages is poor, although when applied to patients with few concealed packages accuracy is high and is useful as a rule-out test. Among patients who have admitted to drug concealment, the number of packages reported to be concealed is reliable. We recommend these patients be given laxatives and observed before performing a single CT to rule out further concealed packages.

**Contributors**

SEA conceived and designed the study, with review and revision by MH and PC. SEA analysed the data and drafted the manuscript, and takes responsibility for the paper as a whole. All authors contributed to collected data and to its revision.

**Competing interests**

None.

**Ethics approval**

South Eastern Sydney Local Health District (Northern Sector) Human Research Ethics Committee.

**Provenance and peer review**

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**REFERENCES**

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