# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction: Urine Output</strong></td>
<td>3</td>
</tr>
<tr>
<td>Intensive monitoring of urine output is associated with increased detection of acute kidney injury and improved outcomes.</td>
<td>4</td>
</tr>
<tr>
<td>Traditional Foley Drainage Systems—Do They Drain the Bladder?</td>
<td>5</td>
</tr>
<tr>
<td>Inaccuracy of Urine Output Measurements due to Urinary Retention in Catheterized Patients in the Burn ICU.</td>
<td>6</td>
</tr>
<tr>
<td><strong>Introduction: Intra-Abdominal Pressure (IAP)</strong></td>
<td>7</td>
</tr>
<tr>
<td>WSACS Recommendations 2013</td>
<td>8</td>
</tr>
<tr>
<td>Is the evolving management of intra-abdominal hypertension and abdominal compartment syndrome improving survival?</td>
<td>9</td>
</tr>
<tr>
<td>Long-term implications of intra-abdominal hypertension and abdominal compartment syndrome.</td>
<td>10</td>
</tr>
</tbody>
</table>
Introduction: Urine Output

Timely, accurate vital signs monitoring can mean the difference between life and death for critically ill patients. But current techniques for gathering this data can be complicated, inaccurate and may increase the risk for urinary infection. (1) Causes of inaccurate readings could be urine retention and urine trapped in the drain line.

The Accuryn Monitoring System transforms the traditional indwelling urinary catheter (IUC) into a next-generation diagnostic tool for precise, real-time measurement of urine output (UO) and core body temperature to help guide care.
Intensive monitoring of urine output is associated with increased detection of acute kidney injury and improved outcomes.

May 17, 2017, Chest 2017

Background
Urine output (UO) is a vital sign for critically ill patients, but standards for monitoring and reporting vary widely between ICUs. Careful monitoring of UO could lead to earlier recognition of acute kidney injury (AKI) and better fluid management. The investigators sought to determine if the intensity of UO monitoring is associated with outcomes in patients with and those without AKI.

Method
This was a retrospective cohort study including 15,724 adults admitted to ICUs from 2000 to 2008. Intensive UO monitoring was defined as hourly recordings and no gaps > 3 hours for the first 48 hours after ICU admission.

Results
» Intensive monitoring for Urine Output was conducted in 4,049 patients (26%)
» Authors found significantly higher rates of AKI in these patients
» After adjustment for age and severity of illness, intensive Urine Output monitoring was associated with improved survival but only among patients experiencing AKI
» With or without AKI, patients with intensive monitoring also had less cumulative fluid volume (2.98 L vs 3.78 L) and less fluid overload (2.49% vs 5.68%) over the first 72 hours of ICU stay

Conclusion
In this large ICU population study the Authors demonstrated:
» Improved detection of AKI
» Reduced 30-day mortality in patients experiencing AKI
» Decrease in fluid overload for all patients

By comparison, intensive monitoring of Serum Creatinine showed no effect on 30-day mortality associated with AKI.
Traditional Foley Drainage Systems—Do They Drain the Bladder?

Garcia MM, Gulati S, Liepmann D, Stackhouse GB, Greene K, Stoller ML.
Traditional Foley drainage systems—do they drain the bladder? J Urol 2007;177:203–7;

Background
It is assumed that Foley catheters drain the bladder completely, but Foley catheter system drainage characteristics are poorly understood.

Method
Bedside bladder ultrasound volumetric studies were performed on 150 hospitalized patients (75 ICU, 75 ward) with indwelling Foley catheters participated in the study. Bladder volumetrics were performed between 07:00 and 08:00, before first ambulation after sleep. Volumetrics were performed independent of scheduled drainage tubing manipulation. If residual urine was identified the drainage tubing was manipulated to facilitate drainage.

Results
Bladder Ultrasound Volumetrics
» Mean residual volume in patients on the ward (38 men, 37 women) and in the ICU (39 men, 36 women) was 136 ml (range 22 to 647) and 96 ml (range 4 to 290), respectively.
» A residual volume of at least 25 ml was documented in ward (48%) and ICU (72%) subjects. In nearly all cases the catheter drainage tubing was milked to induce outflow of residual urine to confirm ultrasound findings.
» A minimum of 50% of the residual volume recorded by ultrasound volumetrics was confirmed.

Conclusion
Contrary to long held assumptions, traditional Foley catheter drainage does not consistently or completely evacuate the bladder. The associated residual urine likely contributes to nosocomial urinary tract infections and myriad other problems that stem from occult incomplete catheter drainage.

Residual urine volumes of patients in ward and ICU

<table>
<thead>
<tr>
<th>Ward measured urine (cc):</th>
<th>No. Pts</th>
</tr>
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<tbody>
<tr>
<td>Less than 25</td>
<td>39</td>
</tr>
<tr>
<td>26-50</td>
<td>6</td>
</tr>
<tr>
<td>51-75</td>
<td>4</td>
</tr>
<tr>
<td>76-100</td>
<td>12</td>
</tr>
<tr>
<td>Greater than 100</td>
<td>14</td>
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<table>
<thead>
<tr>
<th>ICU measured urine (cc):</th>
<th>No. Pts</th>
</tr>
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<tbody>
<tr>
<td>Less than 25</td>
<td>21</td>
</tr>
<tr>
<td>26-50</td>
<td>20</td>
</tr>
<tr>
<td>51-75</td>
<td>13</td>
</tr>
<tr>
<td>76-100</td>
<td>5</td>
</tr>
<tr>
<td>Greater than 100</td>
<td>16</td>
</tr>
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</table>
Compared to the Bard Criticore urine monitor the Accuryn critical care monitoring system with automated drainage tube clearance reduces the airlocks and periods of false oliguria.


Background
Urine output (UO) is the primary physiological sign used to guide fluid therapy during burn resuscitation. Electronic UO monitors can cause inaccurate UO measurements due to the formation of airlocks causing urine retention in the tubing and bladder.

Method
In a multi-center study in burn intensive care units, UO was measured in patients who were randomized into two separate groups:

» A control group using the Criticore electronic urine monitors (Bard Medical) with a standard Foley catheter system (Bard Medical).

» A test group using the Accuryn (Potrero Medical, San Francisco, CA) with automated airlock clearing drainage tubing system.

Results
A total of 18 patients were enrolled in the study with 1 patient in each group participating in the study twice. Performance data was thus generated for 10 patients in the control group and 10 patients in the test group.

» In the control group, 5 of 10 (50%) patients experienced airlocks which impeded drainage line flow. Six associated periods of false oliguria were also noted in the control patients.

» Airlock surge volumes ranged from 50 to 329 ml, and false oliguria duration ranged from 39.4 to 185.2 minutes.

» In the test group, 0 of 10 (0%) patients had drainage line impediments from airlocks (P < .01), and therefore no periods of false oliguria were seen.

![Urine output data: Representative Control Case](image1)

![Urine output data: Extreme Control Case](image2)

![Urine output data: Representative Test Case](image3)
**Introduction:**

**Intra-Abdominal Pressure (IAP)**

Intra-abdominal hypertension (IAH) has a prevalence of at least 50% in the critically ill population and has been identified as an independent risk factor for death. Still, many members of the critical care team are unaware of the consequences of untreated IAH and therefore do not regularly assess for IAH.

This lack of awareness is often compounded by a lack of confidence in traditional IAP measurement methods. Traditional methods for measuring IAP often involve complex setups, increasing the risk for error. Some techniques even require opening the closed drainage system—putting patients at an increased risk for a catheter-associated urinary tract infection (CAUTI).

Nevertheless, there is a strong case for regular measurement of IAP as part of an evidence based protocol. These measurements can be used to better guide patient care to help reduce occurrences and complications of intra-abdominal hypertension and abdominal compartment syndrome. The diagnosis and management of IAH and ACS have changed significantly over time with an improved understanding of the pathophysiology and appropriate treatment of these disease processes.

Serial intra-abdominal pressure (IAP) measurements, nonoperative pressure-reducing interventions, and early abdominal decompression for refractory intra-abdominal hypertension or abdominal compartment syndrome are all key elements of this developing strategy.

Together with these protocols, intra-abdominal pressure readings can empower clinicians to improve clinical outcomes and save patient lives.
WSACS Recommendations 2013

WSACS is the world society of abdominal compartment syndrome. This group of established thought leaders in intra-abdominal pressure and its related pathologies put forth guidelines on when to measure intra-abdominal pressure and how to treat it based on the current body of research. Below is a general outline of how these guidelines can help guide care at facilities.

ICU patients can significantly impact hospital quality measures\(^1\), costs\(^2\) and patient satisfaction scores

Physical exam is an unreliable indicator of IAH/ACS because clinical signs show up late in clinical course (once ACS occurs)\(^3\)

Following WSACS Guidelines Can Improve Outcomes:

- Monitor IAP on all emergency intensive care unit admissions and ‘at risk’ patients\(^1\)
- Early Recognition IAH
- Early Clinical Intervention
- Reduced Organ Failure, mortality and cost\(^2\)

Comprehensive IAH/ACS management strategies that include IAP monitoring deliver improved outcomes and results.


Background
In the past intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS) has been a poorly understood diseases of the traumatically injured patient. Over time, IAH and ACS have been recognized as a significant causes of morbidity and mortality among all types of critically ill patients. In this evolving strategy, serial measurement of intra-abdominal pressure (IAP) have become key in identifying the presence of elevated IAP, an independent predictor of mortality.

Method
This was a prospective observational study of 478 patients to see how an evidence based approach could change survivability amongst patients with IAH/ACS severe enough to require an open abdomen.

Results
» Implementation of a management algorithm in patients with IAH and ACS can improve both clinical outcomes and reduce resource utilization.

» Significant improvement in patient survival to hospital discharge from 50% in 2002 to 72% in 2007 (p=<.015).

» Use of the open abdomen decreased by >50% since the implementation of the World Society of the Abdominal Compartment Syndrome guidelines.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
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<tr>
<td>Mean days to abdominal closure</td>
<td>20 ± 14</td>
<td>17 ± 19</td>
<td>17 ± 14</td>
<td>16 ± 17</td>
<td>13 ± 16</td>
<td>10 ± 10b</td>
</tr>
<tr>
<td>Median days to abdominal closure</td>
<td>20</td>
<td>8</td>
<td>13</td>
<td>12</td>
<td>6a</td>
<td>6a</td>
</tr>
<tr>
<td>Survival to hospital discharge, %</td>
<td>50</td>
<td>57</td>
<td>52</td>
<td>63</td>
<td>69</td>
<td>72a</td>
</tr>
</tbody>
</table>

All other comparisons are statistically significant. *p < .05; **p < .01.
Appropriate management of the patient with IAH/ACS is associated with both significantly improved patient survival and decreased resource use through adoption of a multidisciplinary IAH/ACS management protocol.


Background
» Patient survival after the development of intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS) has improved significantly over the past two decades through improved diagnosis and multidisciplinary management.
» In 2006 and 2007, the World Society of the Abdominal Compartment Syndrome (WSACS) published both evidence-based medicine definitions and recommendations as well as treatment algorithms for the diagnosis, resuscitation, and surgical management of patients with IAH / ACS, which includes IAP as a diagnostic measurement.

Method
Studies from institutions that adopted the use of a multidisciplinary IAH / ACS management protocol were reviewed to show the outcomes achieved.

Results
» Increased awareness of the etiology, prevalence, and patient groups at high risk for IAH/ACS is essential.
» Earlier recognition and appropriate intervention in patients at risk for IAH/ACS, as demonstrated in the studies reviewed, will significantly reduce a hospital’s resource use while at the same time improve patient survival.
» Published mortality rates approaching 100 per cent have been replaced by mortality rates of 20 to 50 per cent depending on age and mechanism of injury.
» These improvements are easily achievable by virtually any hospital through adoption of a multidisciplinary IAH/ACS management protocol.

<table>
<thead>
<tr>
<th></th>
<th>Primary</th>
<th>PAC</th>
<th>Mesh</th>
<th>Skin Only</th>
<th>STSG</th>
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<tbody>
<tr>
<td>Intensive care unit LOS (days)</td>
<td>11 ± 12</td>
<td>21 ± 14</td>
<td>24 ± 14</td>
<td>23 ± 14</td>
<td>32 ± 19</td>
</tr>
<tr>
<td>Hospital LOS (days)</td>
<td>25 ± 21</td>
<td>42 ± 21</td>
<td>44 ± 20</td>
<td>49 ± 22</td>
<td>70 ± 39</td>
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<td>Mechanical ventilation (days)</td>
<td>9 ± 10</td>
<td>19 ± 12</td>
<td>23 ± 16</td>
<td>20 ± 16</td>
<td>31 ± 23</td>
</tr>
<tr>
<td>Definitive closure (days)</td>
<td>5 ± 4</td>
<td>19 ± 9</td>
<td>16 ± 11</td>
<td>21 ± 14</td>
<td>39 ± 23*</td>
</tr>
<tr>
<td>Hospital charges ($1000)</td>
<td>$227 ± 206</td>
<td>$378 ± 209</td>
<td>$491 ± 279</td>
<td>$459 ± 274</td>
<td>$598 ± 335*</td>
</tr>
</tbody>
</table>

* P < 0.0001. PAC, progressive abdominal closure; STSG, split-thickness skin graft; LOS, length of stay.