The Abbreviated Injury Scale scores of subgroups of patients were used to evaluate patterns of injury for helmeted and unhelmeted riders. As expected, the incidence of head injury was higher among the unhelmeted riders (63.81%) than among the helmeted riders (38.95%). In comparison, helmeted riders had higher rates of thoracic injury (47.76%) and extremity injury (80.18%) than did unhelmeted riders (42.05% and 70.46%, respectively) (Table 1).

Differences in total length of stay, number of days in the intensive care unit, and number of days on a ventilator were small. Unhelmeted riders in both categories had slightly longer lengths of stay and increased numbers of days in the intensive care unit (Table 2).

The ICD-9 procedure codes were used to capture the number of patients requiring surgical therapy in various categories. Orthopedic procedures were the most common surgical indication, with orthopedic riders undergoing more orthopedic procedures than unhelmeted riders (35.7% vs 30.0%). A greater percentage of unhelmeted riders required surgery in most of the other categories evaluated (Table 2).

Discussion | In the present study, alcoholism and tobacco use were both independently associated with a decrease in helmet use. This correlation has been shown in previous studies.1-4 Unhelmeted riders were more likely to either self-pay or be covered under government insurance. These trends may reflect a tendency to engage in high-risk behavior while either ignoring or dismissing the potential consequences of these actions.

The data on the Abbreviated Injury Scale scores indicated that helmeted riders had a higher number of injuries to the spine, trunk, and extremities and had significantly more orthopedic procedures. One possible explanation for this is that helmeted riders are surviving higher-force impacts than unhelmeted riders and are thus presenting with more extensive injuries. Helmet use itself may be a factor in contributing to high-impact collisions because a helmeted rider’s increased sense of security may result in a proclivity for higher speeds.

Owing to their significantly higher rate of head injury, unhelmeted patients are expected to have a markedly increased length of stay; however, the higher rates of other injuries among the helmeted group resulted in only slightly longer lengths of stay for unhelmeted patients. Nevertheless, the current trends toward bundled reimbursements and patient-guided satisfaction metrics imply increased costs for even small differences in time of care. Given the change in injury patterns from the head to the rest of the body as a result of helmet use, updated recommendations for the use of supplemental protective gear could be beneficial to both the individual and the health care system.

Jeff Lastfogel, MD, MBA
Tahereh Soleimani, MD
Roberto Flores, MD
Adam Cohen, MD
William A. Wooden, MD
Intizam Munshi, MD, MBA
Sunil S. Tholpady, MD, PhD

Author Affiliations: Department of Surgery, Indiana University, Indianapolis (Lastfogel); Department of Surgery, Division of Plastic Surgery, Indiana University, Indianapolis (Soleimani, Wooden, Tholpady); Department of Plastic Surgery, New York University, New York (Flores); Richard L. Roudebush VA Medical Center, Indianapolis, Indiana (Cohen, Munshi, Tholpady).

Corresponding Author: Sunil S. Tholpady, MD, PhD, Department of Surgery, Division of Plastic Surgery, Indiana University, 705 Riley Hospital Dr, RI 2514, Indianapolis, IN 46202 (stholpaddy@iu.edu).


Author Contributions: Drs Tholpady and Lastfogel had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Lastfogel, Soleimani, Flores, Cohen, Wooden, Tholpady.

Acquisition, analysis, or interpretation of data: Lastfogel, Soleimani, Wooden, Munshi, Tholpady.

Drafting of the manuscript: Lastfogel, Wooden, Tholpady.

Critical revision of the manuscript for important intellectual content: Soleimani, Flores, Cohen, Munshi, Tholpady.

Statistical analysis: Lastfogel, Soleimani, Tholpady.

Administrative, technical, or material support: Munshi, Tholpady.

Study supervision: Flores, Wooden, Tholpady.

Conflict of Interest Disclosures: None reported.

Previous Presentation: This paper was presented at the 39th Annual Meeting of the Association of VA Surgeons; May 4, 2015; Miami Beach, Florida.


Optical Biopsy of Bladder Cancer Using Crowd-Sourced Assessment

Crowdsourcing and optical biopsy are emerging technologies with broad applications in clinical medicine and research. Crowdsourcing, an interactive digital platform that uses multiple individual contributions to efficiently perform a complex task, has been successfully used in diverse disciplines ranging from performance assessment in surgery to optimization of tertiary protein conformations.1,2 Optical biopsy technologies provide real-time tissue imaging with histology-like resolution and the potential to guide intraoperative decision making.3-5 An example is confocal laser endomicroscopy (CLE), which can be used for the diagnosis and grading of bladder cancer.6 To further assess the adoptability of optical biopsy as a diagnostic tool, we applied crowdsourcing to determine the barriers to learning how to diagnose cancer using CLE. We hypothesized that a nonmedically trained crowd could learn to rapidly and accurately distinguish between cancer and benign tissue.

Methods | Amazon Mechanical Turk (Amazon.com) users were recruited as the crowd using a software platform developed by C-SATS. Each crowd worker first completed a validated training modulea and answered a standard screen-
ing question, and then assessed a CLE video sequence randomly selected from a set of 12 sequences derived from a benign (n = 3) or cancerous (n = 9) urothelium (Figure 1). Videos were previously annotated by an expert user (J.C.L.), and diagnoses were confirmed by pathology under a Stanford University institutional review board–approved protocol. For a video to be categorized as showing a cancerous urothelium, correct classification by at least 70% of the crowd, which is the lowest statistical threshold for differentiation from random guessing, was required. Agreement with the expert user by at least 70% of crowd workers was also used to classify microscopic features with 2 categories (papillary structure, organization, morphology, cellular cohesiveness, cellular borders, and vascularity). Crowd workers could elaborate on their observations with free text responses. Additional CLE videos could be reviewed by reentering the system. Each CLE video received a minimum of 100 responses.

A, Each crowd worker was presented with a computer-based CLE training module that included previously validated diagnostic criteria of a cancerous urothelium and a benign urothelium. B, Crowd workers were then asked a test question. An incorrect answer excluded the crowd worker’s responses from subsequent analysis. C, Crowd workers were randomly assigned to evaluate 1 of 12 video sequences. The video sequences consisted of 3 benign urothelia and 9 cancerous urothelia (4 low-grade carcinomas and 5 high-grade carcinomas).
sated 50¢ for each video assessed and blinded to patient history and diagnosis.

**Results** | A total of 1283 ratings from 602 crowd workers were received in 9 hours, 27 minutes. A total of 1173 ratings were eligible for analysis based on correct screening response. The crowd accurately distinguished a cancerous urothelium from a benign urothelium in 11 of 12 video sequences (92%) (Figure 2). The single erroneous classification was of low-grade bladder cancer. In the assessment of microscopic characteristics, the crowds achieved the highest accuracy for cellular borders (10 of 12 video sequences [83%]), followed by vascularity (9 of 12 video sequences [75%]), organization (8 of 12 video sequences [67%]), and cellular cohesiveness (7 of 12 video sequences [58%]). One video was not included in the analysis of cellular morphology (8 of 11 video sequences [73%]) because it contained both monomorphic and pleomorphic cells, but the crowd workers were not given the option to select both. The diagnostic accuracy was lowest for flat vs papillary characterization (6 of 12 video sequences [50%]).

**Discussion** | Hurdles for dissemination of new diagnostic technologies in surgery include clinical validation, overcoming the learning curve, and result interpretation. We hypothesized that crowdsourcing may provide an efficient and cost-effective means for technology evaluation and refinement of the educational curriculum. To validate CLE for intraoperative optical biopsy of bladder cancer, we previously found high diagnostic accuracy and moderate interobserver agreement for image interpretation by 15 novice CLE users, including urological surgeons, pathologists, and engineers. Herein, using crowdsourcing, we efficiently expanded our study to a considerably larger crowd. After a brief training module, the crowd achieved an overall diagnostic accuracy of 92% for cancer classification and exceeded 70% accuracy for cellular borders, vascularity, and cellular morphology. The lower accuracy for cellular cohesiveness, organization, and papillary structure suggests a path toward further refinement of the CLE training curriculum. The limitations of our study include a lack of demographic information for crowd workers and a limited number of video sequences. Overall, the diagnostic accuracy achieved with crowdsourcing demonstrates the relative ease of learning an optical imaging technology for enhanced detection of cancer and a complementary strategy to evaluate new surgical technologies.

Stephanie P. Chen, BS
Sarah Kirsch, BS
Dimitar V. Zlatev, MD
Timothy Chang, MD
Bryan Comstock, MS
Thomas S. Lendvay, MD
Joseph C. Liao, MD

**Author Affiliations:** Department of Urology, Stanford University School of Medicine, Stanford, California (Chen, Zlatev, Chang, Liao); Department of Urology, University of Washington, Seattle (Kirsch, Comstock, Lendvay); VA Palo Alto Health Care System, Palo Alto, California (Liao).

**Corresponding Author:** Joseph C. Liao, MD, Department of Urology, Stanford University School of Medicine, 300 Pasteur Dr, S-287, Stanford, CA 94305-5118 (jliao@stanford.edu).

**Published Online:** September 30, 2015. doi:10.1001/jamasurg.2015.3121.

**Author Contributions:** Ms Chen and Dr Liao had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

**Study concept and design:** Chen, Kirsch, Zlatev, Lendvay, Liao.
**Acquisition, analysis, or interpretation of data:** All authors.
**Drafting of the manuscript:** Chen, Kirsch, Zlatev, Lendvay, Liao.
**Critical revision of the manuscript for important intellectual content:** All authors.
**Statistical analysis:** Zlatev, Comstock.
**Administrative, technical, or material support:** Chen, Kirsch, Zlatev, Chang, Lendvay, Liao.
**Study supervision:** Lendvay, Liao.
Pressure ulcers are pervasive and pose a unique burden on the health care system owing to their association with prolonged hospitalizations and increased costs for patients with chronic medical conditions. These wounds occur frequently in patients with neurological conditions causing immobility and are a significant and common source of patient morbidity. Blocksmma et al initially described muscle flap coverage for paraplegic patients in 1949. Pedicled flap reconstructions, such as the posterior and anterolateral thigh flaps and, more recently, the vastus lateralis myocutaneous flap, have been used in advanced cases with extensive loss of soft tissue or exposed bony structures.2–4

Successful pedicled flap coverage of pressure ulcers, defined as flap survival without flap-related complications during hospital admission (with a survival rate of 87% in this analysis), is determined by several factors, including patient characteristics and comorbidities. To date, there have been no investigations of these determinants using a large, population-based database. We sought to identify factors associated with flap-related complications and increased resource utilization using risk-adjusted, multivariate analysis.

Methods | We searched the National Inpatient Sample (2006–2011) for patients with pressure ulcers (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM] diagnosis codes 707.03–707.05) undergoing pedicled flap reconstruction (ICD-9-CM procedure codes 86.70–86.72) as a primary procedure. Flap-related complications were defined as flap loss, hematoma, seroma, wound infection, or dehiscence, which occurred at a rate of 13% in our cohort. Binary logistic regression models were constructed using the backward stepwise method (initially 69 covariates) to identify predictors for cases associated with complications vs no complications and above vs below median length of stay and total charges. Comorbid diagnoses were defined using ICD-9-CM codes. Cases were weighted to project national estimates. The analyses presented in this study were based on deidentified admission data. The institutional review board at the University of Miami Miller School of Medicine exempted this retrospective database study from full review. Significance for all analyses were set at P < .05.

Results | Overall, 2749 cases were identified. Locations included the sacrococcygeal (63%), trochanteric (22%), and gluteal (14%) regions. The median age of patients at hospital admission was 56 years (interquartile range, 27 years). The mean (SD) length of stay was 14 (19) days. The mean (SD) total charge was $60032 ($88645). Patients were most frequently male (61%), white (68%), with Medicare (58%), and in the lowest income quartile (32%).

On risk-adjusted multivariate analysis, flap-related complications increased for women (odds ratio [OR], 1.64 [95% CI, 1.10–2.44]), patients with renal failure (OR, 4.99 [95% CI, 2.23–11.16]), and obese patients (OR, 1.90 [95% CI, 1.02–3.55]) (Table 1). Trochanteric (OR, 4.54 [95% CI, 2.38–8.33]) and sacrococcygeal (OR, 1.72 [95% CI, 1.02–2.86]) ulcers had more flap-related complications. Length of stay increased for women (OR, 1.69 [95% CI, 1.05–2.78]), patients on Medicaid (OR, 10.4 [95% CI, 4.45–24.47]), patients in the lowest income quartile (OR, 20.0 [95% CI, 8.11–48.31]), patients with wound dehiscence (OR, 7.43 [95% CI, 2.68–20.62]), and patients with renal failure (OR, 7.04 [95% CI, 2.30–21.53]) (Table 2). Sacrococcygeal ulcers portended a longer length of stay (OR, 2.56 [95% CI, 1.33–4.92]). Total charges increased for men (OR, 2.02 [95% CI, 1.32–3.08]), patients on Medicaid (OR, 2.03 [95% CI, 1.04–3.96]), patients in the highest income quartile (OR, 5.88 [3.23–10.0]), patients with pneumonia (OR, 28.0 [95% CI, 4.29–182.90]), and patients with

Table 1. Determinants of Flap-Related Complications Among Patients With Pressure Ulcers Undergoing Pedicled Flap Reconstruction*

<table>
<thead>
<tr>
<th>Category</th>
<th>Odds Ratio (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Female vs male</td>
<td>1.64 (1.10–2.44)</td>
<td>.02</td>
</tr>
<tr>
<td>Asian vs white</td>
<td>4.78 (1.40–16.32)</td>
<td>.01</td>
</tr>
<tr>
<td>Comorbid diagnosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>6.88 (2.15–22.00)</td>
<td>.001</td>
</tr>
<tr>
<td>Renal failure</td>
<td>4.99 (2.23–11.16)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Obesity</td>
<td>1.90 (1.02–3.55)</td>
<td>.04</td>
</tr>
<tr>
<td>Pressure ulcer site</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trochanteric vs gluteal region</td>
<td>4.54 (2.38–8.33)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Sacrococcygeal vs gluteal region</td>
<td>1.72 (1.02–2.86)</td>
<td>.04</td>
</tr>
</tbody>
</table>

*Study cohort derived from Nationwide Inpatient Sample (2006–2011). Selected odds ratios from risk-adjusted multivariate analysis are presented with 95% CIs. Where comparison groups are not listed, the reference group is the absence of the condition (eg, renal failure vs no renal failure). The area under the receiver operating characteristic curve for overall model performance is 0.882 (95% CI, 0.836–0.928; df = 38.

**Conflict of Interest Disclosures:** Mr Comstock and Dr Lendvay are co-owners of C-SATS.

**Funding/Support:** Supported in part by Stanford University School of Medicine Medical Scholars Fellowship to Ms Chen.

**Role of the Funder/Sponsor:** The Stanford University School of Medicine had no role in the design and conduct of the study; collection, management, analysis, or interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

**Additional Contributions:** We thank Justin Warren, MBA, from C-SATS for his technical support in developing the survey pages for crowd workers.