Alcohol Screening and Risk of Postoperative Complications in Male VA Patients Undergoing Major Non-cardiac Surgery

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BACKGROUND: Patients who misuse alcohol are at increased risk for surgical complications. Four weeks of preoperative abstinence decreases the risk of complications, but practical approaches for early preoperative identification of alcohol misuse are needed.

OBJECTIVE: To evaluate whether results of alcohol screening with the Alcohol Use Disorders Identification Test - Consumption (AUDIT-C) questionnaire—up to a year before surgery—were associated with the risk of postoperative complications.

DESIGN: This is a cohort study.

SETTING AND PARTICIPANTS: Male Veterans Affairs (VA) patients were eligible if they had major noncardiac surgery assessed by the VA's Surgical Quality Improvement Program (VASQIP) in fiscal years 2004-2006, and completed the AUDIT-C alcohol screening questionnaire (0-12 points) on a mailed survey within 1 year before surgery.

MAIN OUTCOME MEASURE: One or more postoperative complication(s) within 30 days of surgery based on VASQIP nurse medical record reviews.

RESULTS: Among 9,176 eligible men, 16.3% screened positive for alcohol misuse with AUDIT-C scores ≥ 5 , and 7.8% had postoperative complications. Patients with

AUDIT-C scores ≥ 5 were at significantly increased risk for postoperative complications, compared to patients who drank less. In analyses adjusted for age, smoking, and days from screening to surgery, the estimated prevalence of postoperative complications increased from 5.6% (95% CI 4.8–6.6%) in patients with AUDIT-C scores 1–4, to 7.9% (6.3–9.7%) in patients with AUDIT-Cs 5–8, 9.7% (6.6–14.1%) in patients with AUDIT-Cs 9–10 and 14.0% (8.9–21.3%) in patients with AUDIT-Cs 11–12. In fully-adjusted analyses that included preoperative covariates potentially in the causal pathway between alcohol misuse and complications, the estimated prevalence of postoperative complications increased significantly from 4.8% (4.1–5.7%) in patients with AUDIT-C scores 1–4, to 6.9% (5.5–8.7%) in patients with AUDIT-Cs 5–8 and 7.5% (5.0–11.3%) among those with AUDIT-Cs 9–10.

CONCLUSIONS: AUDIT-C scores of 5 or more up to a year before surgery were associated with increased postoperative complications.

KEY WORDS: alcohol screening; surgical outcomes; AUDIT-C.

J Gen Intern Med 26(2):162–9

DOI: 10.1007/s11606-010-1475-x

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Electronic supplementary material The online version of this article (doi:10.1007/s11606-010-1475-x) contains supplementary material, which is available to authorized users.

Received September 18, 2009

Revised February 5, 2010

Accepted July 7, 2010

Published online September 28, 2010

INTRODUCTION

Alcohol misuse is increasingly recognized as a common and modifiable risk factor for surgical complications.^{1–3} Surgical

patients who drink over 4 drinks daily have 2-3 fold increased risk for postoperative complications compared to patients who drink less than 2 drinks daily.⁴⁻⁷ Alcohol misuse is associated with increased cardiopulmonary, infectious, wound, bleeding and neurologic complications.⁸

One month of monitored preoperative abstinence significantly decreased postoperative complications in a randomized controlled trial of surgical patients who drank over 4 drinks daily; 31% versus 74% had any complication(s).² The duration of abstinence required to reverse alcohol's adverse physiologic effects varies from 2-8 weeks for different organ systems,³ and a trial of brief alcohol interventions closer to the time of surgery found no benefit.⁹ Therefore, prevention of alcohol-related surgical complications requires identification of high risk alcohol use earlier than most preoperative anesthesia visits, potentially when patients are referred for surgical consultation or scheduled for surgery.

Early identification of patients who might benefit from preoperative abstinence requires a practical way to identify those at risk for alcohol-related surgical complications. However, simple questions about typical quantity and frequency of drinking are insensitive.¹⁰ Although often recommended,¹ these and other unsystematically implemented or nonstandard alcohol assessments miss 50% of surgical patients with alcohol misuse.¹¹ One possible approach to early preoperative identification of alcohol misuse would be to use results of alcohol screening conducted as part of routine preventive care. This study evaluated whether results of alcohol screening with the AUDIT-C, administered up to a year before surgery, were associated with the risk of postoperative complications in men undergoing major noncardiac surgery in the VA.

METHODS

Study Sample and Data Sources

Male VA patients were eligible for this study if they underwent noncardiac surgeries assessed by the VA's Surgical Quality Improvement Program (VASQIP) between October 2003 and September 2006, and completed the AUDIT-C on the Survey of Healthcare Experiences of Patients (SHEP) in the 12 months prior to surgery (response rate 62.1% during study). Women were excluded because only 27 of 492 eligible had postoperative complications. Figure 1 shows other exclusions.

Surgical data were obtained from VASQIP, which collects standardized preoperative, intraoperative and postoperative clinical data for patients who undergo major surgery in VA. Major non-cardiac surgery is defined as inpatient or outpatient surgery with significant operative morbidity or mortality,^{12, 13} excluding coronary bypass, thoracic aortic great vessel procedures, or surgeries requiring cardiopulmonary bypass.¹⁴ Each VA medical center that conducts major surgery has a VASQIP nurse who reviews medical records and assesses 30 day postoperative complications.¹⁵

The AUDIT-C and demographic covariates were obtained from SHEP, the VA's nationwide patient satisfaction survey, mailed monthly to a stratified random sample of outpatients

Figure 1. Study sample.

with recent visits.¹⁶ Additional administrative data were obtained from the VA National Patient Care Database (NPCD).

The University of Washington and VA Puget Sound Human Subjects Committees and institutional review boards at co-authors' institutions approved the study.

Measures

AUDIT-C alcohol screening in the year prior to surgery. The primary independent measure was the AUDIT-C (Box 1), a validated screen for drinking above recommended limits and/or alcohol use disorders.^{17, 18} AUDIT-C scores (0-12 points) were used as a scaled measure of risk with the a priori hypothesis that patients with the highest scores would be at highest risk for postoperative complications, and that nondrinkers would be at greater risk than low-level drinkers.¹⁹⁻²² AUDIT-C scores up to a year before surgery were used, consistent with the timeframe of annual preventive screening. AUDIT-C scores were grouped into 5 empirically-defined surgical risk groups for ease of reporting and increased precision (described below).²³

Secondary alcohol screening measures. Drinking over 2 drinks daily is commonly used to assess alcohol misuse preoperatively,⁸ whereas single-item screening questions about episodic "binge" drinking, including AUDIT-C question #3, have been validated as brief alcohol screening tests.^{17, 24-27} To evaluate whether either of these brief alcohol screening approaches was associated with the risk of postoperative complications, two additional alcohol screening measures were derived from the AUDIT-C: 1) drinking over 2 drinks most days (≥ 4 days/week) on questions #1-2; and 2) the frequency of drinking 6 or more drinks on an occasion on question #3 (Box 1).

Box 1. AUDIT-C questionnaire on SHEP

AUDIT-C question #1: "How often did you have a drink containing alcohol in the past 12 months?" with response options "Never (0 points), Monthly or less (1 point), 2-4 times a month (2 points), 2-3 times a week (3 points), and 4 or more times a week (4 points)."

AUDIT-C question #2: "How many drinks containing alcohol did you have on a typical day when you were drinking in the past 12 months?" with response options "0 drinks (0 points), 1-2 drinks (0 points), 3-4 drinks (1 point), 5-6 drinks (2 points), 7-9 drinks (3 points) and 10 or more drinks (4 points)."

AUDIT-C question #3: "How often did you have 6 or more drinks on an occasion in the past 12 months?" with response options "Never (0 points), Less than monthly (1 point), Monthly (2 points), Weekly (3 points) and Daily or almost daily (4 points)."

AUDIT-C scores are the sum of points from each question (range 0-12 points).

Outcome Measure – Postoperative Complication(s). The main outcome measure was any postoperative complication(s) in the 30 days after surgery, a composite measure based on 20 complications monitored by VASQIP during the study period.²⁸ Complications were grouped into 5 subtypes associated with alcohol misuse: surgical field complications, infectious complications other than surgical site infections (SSI), cardiopulmonary complications, neurologic complications, and bleeding complications.^{4,5,29-31} *Surgical field complications* included wound disruption, graft prosthesis failure, organ/space surgical site infection, and superficial and deep wound infections. *Infectious complications other than SSI* included pneumonia, urinary tract infection, and postoperative systemic sepsis. *Cardiopulmonary complications* included myocardial infarction, cardiac arrest requiring cardiopulmonary resuscitation, failure to

wean off a ventilator in 48 hours postoperatively, and re-intubation. *Neurologic and bleeding complications* occurred in insufficient numbers to evaluate separately, so were combined with all other complications monitored by VASQIP: stroke, coma > 24 hours, peripheral nerve injury, bleeding requiring > 4 units, deep venous thrombosis or thrombophlebitis, pulmonary embolism, acute renal failure, and progressive renal insufficiency.

Delirium was ascertained as a secondary outcome from the NPCD based on ICD-9 discharge or outpatient diagnoses in the 30 postoperative days. Postoperative delirium occurs in 9-11% of surgical patients and is increased in patients who use and abuse alcohol.³²⁻³⁵ VASQIP does not monitor alcohol withdrawal and the ICD code for withdrawal (291.81) was expected to be too insensitive to use as an outcome.

Covariates. Covariates included age, race and marital status from SHEP, disability due to military service from NPCD, and time from AUDIT-C to surgery. Cigarette smoking status in the past year,³⁶ the American Society of Anesthesiologists classification (ASA class) documented by anesthesiologists, and the surgical facility were obtained from VASQIP. Additional covariates were selected from 45 pre-operative measures collected by VASQIP that have demonstrated superiority over other measures for surgical risk-adjustment.³⁷ The Deyo index was constructed based on past-year inpatient and outpatient NPCD ICD-9 codes and used to further adjust for comorbidity.³⁸ Relative value units (RVUs) of the primary procedure were used to adjust for surgical complexity.³⁹

Figure 2. Prevalence of postoperative complications across AUDIT-C surgical risk groups. Adjusted prevalence rates and 95% confidence intervals estimated from random effects logistic regression, Model 1, adjusted for age, smoking and time from AUDIT-C to surgery, and Model 2, fully-adjusted, with p values for comparison with the referent group (AUDIT-C scores 1-4). † Total complications=one or more of the 20 postoperative complications assessed by VASQIP in the 30 postoperative days.

Surgeries were classified as emergent based on VASQIP criteria, and grouped into five categories for descriptive purposes based on primary Common Procedural Terminology (CPT) codes.

Analyses

Descriptive analyses evaluated characteristics of the study sample. Five AUDIT-C surgical risk groups were derived empirically based on the adjusted prevalence of postoperative complications associated with each AUDIT-C score (0-12), estimated from multivariable random effects logistic regression models that included a random facility effect and adjusted for age, smoking and time from AUDIT-C to surgery (See online Appendix A).¹⁹⁻²² The resulting AUDIT-C surgical risk groups were AUDIT-C scores: 0 (nondrinkers); 1-4 (low risk); 5-8 (moderate risk); 9-10 (high risk); and 11-12 (highest risk).

Unadjusted analyses and two sets of adjusted analyses estimated the prevalence of any postoperative complication(s) across AUDIT-C surgical risk groups. Both sets of adjusted analyses used multivariable random effects logistic regression to test whether AUDIT-C surgical risk groups were associated with postoperative complication(s), accounting for correlated data from the same facility. Patients who reported low-level drinking were designated the referent group *a priori* because nondrinkers in VA have poorer health status and greater morbidity and mortality.^{19, 21, 40} Analyses of the two secondary alcohol screening measures derived from the AUDIT-C were conducted in parallel fashion.

The first set of models (Model 1) assessed associations between AUDIT-C screening measures and postoperative complications, adjusting for age, smoking, and time from AUDIT-C to surgery, because both age and smoking are strong confounders of the association between alcohol use and health, making unadjusted associations difficult to interpret. Results of Model 1 provide information that can be used to educate patients and providers about surgical risks associated with varying AUDIT-C scores after accounting for these confounders.

The second set of fully-adjusted models (Model 2) added the following covariates to Model 1: ASA class; the Deyo comorbidity index; RVUs; and 11 preoperative VASQIP variables associated with the AUDIT-C ($p < 0.05$) and with postoperative complications ($p < 0.2$) in a forward stepwise logistic regression model. Model 2 sought to assess the independent association between AUDIT-C scores and postoperative complications but included covariates which could be in the causal pathway between alcohol misuse and postoperative complications (e.g. elevated GOT), potentially "over-adjusting."

Analyses of secondary outcomes (subtypes of VASQIP complications and delirium) were conducted in a parallel fashion to Model 1, but not Model 2 due to smaller numbers of outcomes. For delirium, the two highest AUDIT-C risk groups were collapsed into a single group due to relatively few patients with documented delirium.

Exploratory analyses tested whether there were significant interactions between AUDIT-C surgical risk groups and the following covariates in Model 1: age (< 50 ; $50-64$; ≥ 65), time

from AUDIT-C to surgery (< 4 months; $4-8$ months; > 8 months), RVUs in terciles, and inpatient versus outpatient surgeries.

All analyses were conducted using STATA 10.⁴¹

RESULTS

A total of 9,176 men completed the AUDIT-C on mailed surveys in the year prior to surgery and were eligible for this study (Fig. 1). Most were over 60 years old (mean age 64; range 21-90+ years), non-Hispanic White, and married or widowed. Surgeries were conducted at 106 VA facilities, most often for gastrointestinal or musculoskeletal conditions. Most patients were classified as ASA class 3, and fewer than a third smoked cigarettes (Table 1).

Of the total sample, 16.3% (95% CI 15.6-17.1%) screened positive for alcohol misuse with AUDIT-C scores of 5-12, 8.3% (7.8-8.9%) reported drinking over 2 drinks most days, and 22.6% (21.8-23.5%) reported drinking 6 or more drinks on an occasion in the past year (Table 1). Patients who screened positive for alcohol misuse with AUDIT-C scores ≥ 5 were younger, less likely to be married or widowed, more likely to be divorced or separated, less likely to be disabled due to military service, and more likely to smoke, compared to drinkers with lower AUDIT-C scores (See online Appendix B). Those who screened positive for alcohol misuse with AUDIT-C scores 9-12 had greater comorbidity than drinkers with lower AUDIT-C scores (See Online Appendix B).

AUDIT-C Scores and Postoperative Complications

Overall, 718 (7.8%; 7.3-8.4%) patients had one or more postoperative complications, and AUDIT-C scores were significantly associated with the risk of complications ($p < 0.0005$). The unadjusted prevalence of complications (Table 2) was lowest among patients with AUDIT-C scores 1-4 (6.3%) and highest among those with AUDIT-C scores 11-12 (14.4%).

Adjusted prevalence rates of postoperative complications across the AUDIT-C groups were similar to unadjusted prevalence rates (Table 2) after adjustment for age, smoking, and time from the AUDIT-C to surgery (Model 1). There were no significant interactions between AUDIT-C surgical risk groups and age, RVUs, or inpatient surgery, but there was a near-significant interaction with time from AUDIT-C to surgery (< 4 months; $4-8$ months; ≥ 8 months; $p = 0.051$), with higher risks associated with alcohol misuse when there was less time between AUDIT-C screening and surgery.

In the fully-adjusted model (Model 2), the estimated prevalence of postoperative complications was lower in all AUDIT-C groups than in Model 1, with the risk most attenuated among patients with higher AUDIT-C scores (Fig. 2). However, significant associations between alcohol misuse and postoperative complications persisted, with the exception of the relatively small group of 132 patients with AUDIT-C scores 11-12 (Table 2).

Specific Types of Complications

Three subtypes of complications—surgical field complications, infections other than SSI, and cardiopulmonary complications—

Table 1. Characteristics of the Study Sample of Male VA Surgery Patients (n=9,176)

	N (%)
Age	
<50	695 (7.6)
50-59	2700 (29.4)
60-69	2803 (30.6)
≥70	2978 (32.5)
Race ^a	
White (non-Hispanic)	7478 (82.7)
Black (non-Hispanic)	741 (8.2)
Hispanic	464 (5.1)
Other	358 (4.0)
Marital status ^a	
Married or widowed	5818 (64.6)
Divorced or separated	2612 (29.0)
Never married	583 (6.5)
≥ 50% service connected disability	1938 (21.1)
Deyo co-morbidity Index ≥ 3	1308 (14.3)
Emergency surgery	365 (4.0)
ASA classification ^b	
1	120 (1.3)
2	2792 (30.4)
3	5694 (62.1)
4-5	570 (6.2)
Inpatient surgeries	5975 (65.1)
Type of surgery	
Gastro-intestinal	3059 (33.3)
Musculoskeletal	3018 (32.9)
Cardiovascular or thoracic	1202 (13.1)
Genitourinary	1496 (16.3)
Other ^c	401 (4.4)
Past-year smoking (from clinical documentation)	2814 (30.7)
AUDIT-C ^d surgical risk groups (AUDIT-C scores)	
Nondrinkers (0)	4252 (46.3)
Low risk drinkers (1-4)	3425 (37.3)
Moderate risk drinkers (5-8)	1109 (12.1)
High risk drinkers (9-10)	258 (2.8)
Highest risk drinkers (11-12)	132 (1.4)
Typical daily drinking (AUDIT-C Q#1-2)	
No more than 2 drinks daily	8411 (91.7)
> 2 drinks/day, ≥ 4 days/week	765 (8.3)
AUDIT-C ^d Question #3 (frequency of 6 or more drinks)*	
Never	6901 (75.2)
Less than monthly	908 (9.9)
Monthly	478 (5.2)
Weekly	388 (4.2)
Daily or almost daily	244 (2.7)

^a Numbers do not sum to column totals and percents do not total 100 due to missing values

^b ASA=American Society of Anesthesiologists

^c Other=Skin & soft tissue, hematologic/lymphatic, endocrine, and nervous system

^d AUDIT-C from mailed Survey of Healthcare Experiences of Patients (SHEP) in the 12 months prior to surgery

had a similar dose-response pattern of risk to that observed for all complications combined (Table 3; See Online Appendix C). Compared to low risk drinkers, patients with AUDIT-C scores ≥ 5 were at increased risk for surgical field and cardiopulmonary complications, and patients with scores ≥ 9 were at increased risk for infections (Table 3).

Patients with AUDIT-C scores 5-8 were also at increased risk for postoperative delirium compared with low risk drinkers (Table 3; See Online Appendix C). There was no increased risk of delirium among patients with AUDIT-C scores 9-12 in whom delirium was relatively uncommon, with only 14 of 390 patients in this group having postoperative delirium.

Secondary Screening Measures Derived from the AUDIT-C

Patients were at increased risk for postoperative complications if they reported drinking over 2 drinks most days (Table 2). However, drinking 6 or more drinks on an occasion weekly or less often was not associated with increased risk (Table 2), and this lack of association persisted when nondrinkers were excluded from the referent group of patients who never drank 6 or more drinks on an occasion (data not shown).

DISCUSSION

This study found that male VA patients who screened positive on the AUDIT-C with scores of 5 or more up to a year before major surgery were at increased risk for postoperative complications compared to low risk drinkers. There was a dose-response relationship between AUDIT-C scores and postoperative complications, with complications increasing from 5.6% among low risk drinkers to 14.0% among those with the highest AUDIT-C scores, in analyses adjusted for age, smoking, and time from screening to surgery. Three types of complications known to be associated with alcohol misuse increased as AUDIT-C scores increased: surgical field, infectious, and cardiopulmonary complications. After adjustment for preoperative comorbidity and surgical complexity, patients with AUDIT-C scores of 5 or more had a 40-50% increased risk of postoperative complications.

Findings of this study are consistent with extensive prior research demonstrating a strong association between alcohol misuse and postoperative complications.³ Both heavy daily drinking (> 2-4 drinks/day) and alcohol use disorders are known to be associated with increased surgical complications.^{3-8, 31}

This study extends prior research in several important ways. Clinicians and researchers need a practical, yet sensitive test to identify patients at risk for alcohol-related postoperative complications, and this study suggests that the AUDIT-C could meet that need. Directly asking patients if they drink over 2 or 4 drinks/day misses many patients with alcohol misuse who might benefit from preoperative alcohol abstinence.^{3,7,8} Therefore, studies of alcohol misuse and surgical complications have often used complex assessment protocols that are impractical for general medical settings.^{31,42-44} The 10-item Alcohol Use Disorders Identification Test (AUDIT) is a sensitive alcohol screen that can identify patients at increased risk for postoperative complications,^{45,46} but is too long for routine use in many clinical settings.⁴⁷

This study showed that the AUDIT-C, which is as effective an alcohol screen as the full AUDIT^{17,18,48} but brief enough for integration into routine care,^{23,49} could be used to identify patients at risk for alcohol-related postoperative complications. Further, the AUDIT-C identified almost twice as many patients (16.3%) compared to report of typical drinking over 2 drinks daily (8.3%). Moreover, patients who screened positive on the AUDIT-C were at increased surgical risk even though the screen was administered up to a year prior to surgery, suggesting that annual AUDIT-C screening results could be used for early preoperative identification of patients at risk for alcohol-related surgical complications.

Table 2. 30-day Postoperative Complications: Association with Alcohol Screening Measures Completed up to a Year Prior to Surgery (n=9,176)

	30-Day Postoperative Complications		
	Unadjusted prevalence N (%)	Adjusted prevalence % (95% CI)	
		Age and smoking adjusted model ^a	Fully adjusted model ^b
AUDIT-C surgical risk groups			
0	361 (8.5)	7.1 (6.2-8.2) ^e	5.7 (5.0-6.6)
1-4 (Referent group)	216 (6.3)	5.6 (4.8-6.6)	4.8 (4.1-5.7)
5-8	95 (8.6)	7.9 (6.3-9.7) ^d	6.9 (5.5-8.7) ^d
9-10	27 (10.5)	9.7 (6.6-14.1) ^d	7.5 (5.0-11.3) ^c
11-12	19 (14.4)	14.0 (8.9-21.3) ^e	7.5 (4.3-12.8)
Typical daily drinking (AUDIT-C Q#1-2)			
No more than 2 drinks daily	634 (7.5)	6.5 (5.8-7.4)	5.5 (4.8-6.2)
> 2 drinks/day, at least 4 days/week	84 (11.0)	9.8 (7.8-12.2) ^e	7.1 (5.5-9.1)
Frequency of ≥ 6 drinks (AUDIT-C Q#3)			
Never (referent group)	538 (7.8)	6.6 (5.8-7.5)	5.5 (4.8-6.2)
Less than monthly	64 (7.1)	6.7 (5.2-8.6)	5.4 (4.1-7.1)
Monthly or more often	35 (7.3)	6.9 (4.9-9.7)	6.0 (4.2-8.5)
Weekly	35 (9.0)	8.3 (5.9-11.6)	7.3 (5.1-10.4)
Daily or almost daily	30 (12.3)	11.6 (8.0-16.4) ^e	6.8 (4.4-10.3)

^a Age and smoking adjusted Model 1 was adjusted for age, smoking status, and time from AUDIT-C to surgery in random effects logistic regression models accounting for clustering at the facility level

^b Fully-adjusted Model 2 added covariates: ASA class, 11 preoperative VASQIP variables (emergency surgery, preoperative sodium ≤ 135, dyspnea, bleeding disorder, hematocrit ≤ 38, chronic obstructive pulmonary disease, hemiplegia, history of transient ischemic attack, renal failure, disseminated cancer, and serum GOT > 40), the Deyo Index to adjust for comorbidity, and relative value units (RVUs) to adjust for the complexity of the surgical procedure

^c Comparison to referent group, $p < 0.05$

^d Comparison to referent group, $p < 0.01$

^e Comparison to referent group, $p < 0.005$

The finding that episodic heavy drinking was not associated with increased risk of surgical complications was unexpected and has important implications. Validated single-item alcohol screening questions that ask about heavy episodic drinking are increasingly recommended for alcohol screening.²⁴⁻²⁶ This study suggests that these screens are not effective for identifying patients at risk for alcohol-related surgical complications.²⁴

This study has several limitations. The AUDIT-C was administered on confidential mailed surveys which may yield higher scores than screening in clinical settings.⁵⁰ Although the fully-adjusted model controlled for extensive covariates, residual confounding is possible. For example, if patients with alcohol misuse were more likely to have high risk surgical

procedures, after adjustment for RVUs, study findings could be confounded by the type of procedure. Furthermore, the main outcome measure combined complications of varying clinical importance. In addition, 9% of patients were excluded due to non-response, potentially decreasing generalizability since surgical risks may differ for non-respondents, who tend to be younger. Similarly, the study included predominantly older men, and thus is not necessarily generalizable to women or younger men. Additional research is needed to verify AUDIT-C surgical risk groups when screening is conducted in clinical settings, and to evaluate associations between the AUDIT-C and postoperative complications in more demographically diverse samples with higher response rates, and in patients undergoing the same surgical procedure.

Table 3. Age- and Smoking-adjusted Prevalence of Subtypes of Postoperative Complications Across AUDIT-C Surgical Risk Groups^a

	AUDIT-C Surgical Risk Groups (AUDIT-C scores) ^b				
	Non-drinkers	Drinkers			
	(0)	Low risk (1-4)	Moderate risk (5-8)	High risk (9-10)	Highest risk (11-12)
Complications:	% (95% CI)				
Surgical field	3.1 (2.5 3.7)	2.7 (2.2 3.4)	3.8 (2.8 5.1) ^d	3.9 (2.2 6.9)	4.4 (2.1 9.2)
Infectious other than SSI	2.6 (2.1 3.2)	2.1 (1.6 2.7)	2.9 (2.0 4.0)	4.6 (2.6 8.1) ^e	5.2 (2.4 10.9) ^d
Cardio-pulmonary	1.5 (1.1 1.9) ^f	0.7 (0.5 1.1)	1.5 (0.9 2.4) ^e	3.0 (1.5 5.9) ^f	4.1 (1.8 9.2) ^f
Other	1.6 (1.2 2.1) ^e	1.0 (0.7 1.4)	1.4 (0.9 2.3)	2.9 (1.4 5.9) ^e	1.5 (0.4 6.0)
Postoperative delirium ^c	4.0 (3.4 4.7)	3.3 (2.8 4.0)	4.9 (3.7 6.4) ^d	3.6 (2.1 6.1)	

^a Adjusted for age, smoking status, and time from AUDIT-C to surgery

^b Reference group: patients with AUDIT-C scores 1-4

^c From administrative data; for analyses of delirium, the two highest risk AUDIT-C groups (scores 9-12) were combined for all analyses due to small numbers with delirium

^d Comparison to referent group, $p < 0.05$

^e Comparison to referent group, $p < 0.01$

^f Comparison to referent group, $p < 0.005$

Despite these limitations, this study has several important strengths. The AUDIT-C was administered in a standard fashion and was available for a large, national sample of men who completed alcohol screening in the year prior to surgery. Additionally, assessment of outcomes was standardized and abstractors were blinded to AUDIT-C results and unaware of this study.

This study has several implications for general medicine practice. Health care systems are increasingly implementing alcohol screening so that patients with alcohol misuse can be offered brief alcohol interventions.^{23, 49, 51} Routine AUDIT-C screening could also be used for early identification of patients at risk for alcohol-related surgical complications. Health systems using the AUDIT-C could incorporate review of alcohol screening results into surgical referrals or nursing assessments when surgery is scheduled. Patients with scores ≥ 5 whose drinking has not changed at the time of referral to surgery could be counseled that their drinking puts them at increased risk for serious complications and encouraged to abstain preoperatively. Available evidence from a single trial suggests that abstaining for a month preoperatively significantly reduces postoperative complications.² The high participation rate in that trial² suggested that many patients are willing to abstain temporarily in an attempt to decrease surgical risks.

To summarize, the AUDIT-C provides a sensitive and practical way to identify preoperative patients at risk for alcohol-related surgical complications. Alcohol screening with the AUDIT-C up to a year prior to surgery, as in routine annual alcohol screening, identified over 16% of men undergoing major surgery who were at increased risk for alcohol-related surgical morbidity. Preoperative strategies to reduce alcohol-related surgical complications should now be further tested in this high-risk group. In the meantime, patients with AUDIT-C scores ≥ 5 should be encouraged to abstain for the month preoperatively, and those requiring urgent or emergent surgeries should be managed expectantly with regard to postoperative complications.

Acknowledgements: The authors greatly appreciate the VA Surgical Quality Data Use Group (SQDUG) and the VA Office of Quality and Performance (OQP), which shared their data with us for this project. The project would not have been possible without these data. The authors would like to further acknowledge SQDUG for its role as scientific advisors and for the critical review of data use and analysis presented in this manuscript.

Contributors: The authors would also like to thank Drs. Bevan Yueh and Emily Williams for important contributions to the design of the study and Mr. Jeff Todd-Stenberg for acquisition and merging of data.

Financial Support: The research reported here was supported by the Department of Veterans Affairs, Veterans Health Administration, Office of Research and Development and Health Services Research and Development (project IAC 06-021). Dr. Bradley is an investigator at the VA Northwest HSR&D Center of Excellence and at the Center of Excellence in Substance Abuse Treatment and Education, VA Puget Sound Health Care System, Seattle, WA.

Prior Presentation: A portion of this work was presented at the 2009 VA Health Services Research & Development National Meeting as an oral presentation and at the 2009 VA National Leadership Board Meeting and 2009 American Society of Anesthesiologists Meeting as a poster.

Conflict of Interest: The authors certify that we have no affiliation with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the manuscript (e.g., employment, consultancies, stock ownership, honoraria).

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