

Alcohol Misuse Prevalence and Associations with Post-Operative Complications in US Surgical Patients: A Review

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Abstract: We conducted a standardized review of research on the prevalence of alcohol use or misuse (including alcohol use disorders), and the association of alcohol use or misuse with post-operative surgical complications among US patients. Twenty seven studies that included a preoperative measure of alcohol use or misuse and included at least 50 US surgical patients were identified using a standardized search strategy (1950-April 2007). Twenty-two of the studies reported prevalence of alcohol use or misuse, which was highest in major otolaryngology surgeries (mostly for cancer and injuries: 22-88.5%) and thoracic surgery (lung transplant and cancer resections: 29-33%) and ranged from 8-28% in the remaining studies. Nineteen studies examined the association between pre-operative alcohol consumption and post-operative complications suggesting positive associations between alcohol use or misuse and risk for post-operative delirium, pneumonia, cognitive decline, overall complications, and death. Most identified studies had methodological limitations, especially the widespread use of drinking assessment methods that cannot distinguish alcohol use from misuse.

BACKGROUND

In Europe, 7% to 49% of surgical patients drink over 60 grams of alcohol daily (> 4 US drinks daily) [1-14], which has been associated with 2- to 4-fold increases in post-operative complications. Drinking above this level has been associated with cardiopulmonary, hematological, infectious, neurological and wound healing complications, as well as increased post-operative mortality compared with low-level drinking [12, 13, 15, 16]. Moreover, a randomized controlled trial of Danish patients who drank at this level demonstrated that 4 weeks of preoperative abstinence from alcohol markedly decreased post-operative complications [1]. Most of this research has been conducted in two countries, Denmark and Germany. However, the prevalence of alcohol misuse may be higher in European countries than in the US and patterns of drinking vary between the US and European countries [17, 18], so it is unknown whether findings from these studies generalize to the US.

The purpose of this study was to conduct a standardized review of the literature on alcohol use and misuse in US surgical populations. Alcohol misuse includes the spectrum from risky drinking to alcohol use disorders (including alcohol abuse and alcohol dependence) [19, 20]. Risky drinking refers to drinking above the National Institute on Alcohol Abuse and Alcoholism's (NIAAA) recommended limits of no more than 7 drinks per week for women and 14 drinks per week for men and no more than 3 drinks on an occasion for women and 4 drinks on an occasion for men. Specifically,

we sought to address three questions. First, what is the prevalence of alcohol use or misuse among US surgical patients? Second, what is known about the association between alcohol use or misuse and post-operative surgical complications in US surgical populations? Finally, what are the methodological strengths and limitations of previous studies of alcohol misuse among US surgical populations?

METHODS

Search Strategy

PubMed was searched from 1950 through 2005 using the terms "surgery," "alcohol drinking," and "complications" and other similar terms in December of 2005. The search was updated April of 2007. Citations of identified studies and prior reports [9, 10, 14, 21] were also reviewed for potentially eligible studies.

Review Inclusion Criteria

Studies were included in this review if they sampled from a US surgical population, included any preoperative measure of alcohol use or misuse, and included at least 50 patients. A list of all identified articles was reviewed by an anesthesiologist (MB) and a general surgeon (MH) with interest in alcohol misuse and surgical outcomes, and a biostatistician health services researcher with expertise in surgical quality improvement (WH). They did not identify any additional studies that met eligibility criteria.

Data Abstraction

Two authors (MF and AH) independently abstracted the following elements from the 27 identified articles: (a) author and year; (b) setting and population characteristics (e.g., teaching hospital, lung cancer patients); (c) source of alcohol data (e.g., research assessment, medical record review); (d)

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alcohol measure used when specified (e.g., CAGE); (e) total sample size(s) and (f) prevalence(s) of alcohol use or misuse; as well as (g) risk or odds ratios of complications or other surgical outcomes if reported by level of alcohol use or misuse. After data were independently extracted, results were compared, and discrepancies were identified and resolved by consensus of all authors. When not presented in publications, we calculated relative risk or odds ratios if adequate data were available.

Methodological Quality

Although evaluation of the methodological quality of each article had been planned, marked limitations in the majority of identified studies resulted in inadequate variability to make quantitative quality ratings meaningful. Instead, major limitations in the internal and external validity of identified studies are addressed using a descriptive approach.

RESULTS

Studies Meeting Inclusion Criteria for Review

Twenty seven studies of US surgical patients were identified that met inclusion criteria [22-49]. Twenty two of these studies reported alcohol use/misuse prevalence (Table 1) and 19 evaluated alcohol-related post-operative complications (Table 2). Seven of the 27 studies described alcohol use or misuse in mixed samples of patients undergoing different types of non-cardiac surgeries [22-28], and three of those seven used data from the Veterans Affairs (VA) National Surgical Quality Improvement Program (NSQIP) [22-24]. One other study described and compared the prevalence of alcohol misuse across different surgical subspecialties [29], and one study was limited to vascular or thoracic patients admitted to ICU post-operatively [30]. Two studies described the prevalence of alcohol misuse and associated complications in cardiac surgery patients [39, 40]. The remaining studies were case series of patients undergoing specific procedures.

Prevalence of Alcohol Use and Misuse in US Surgical Patients

The prevalence of alcohol use and misuse varied depending on the characteristics of the surgical samples under investigation as well as the alcohol measures used (Table 1).

Non-cardiac surgery. In 3 studies of patients undergoing major non-cardiac surgery, the prevalence of medical record documentation of drinking more than 2 drinks per day in the 2 weeks prior to patient surgery were 9.6% in patients > 65 years old at one site [25] and 15.2% and 11.2% in 2 large multisite studies [22, 23]. Another study of major non-cardiac surgery patients found that 7.7% reported "...a current problem drinking too much alcohol" [27].

Major Cardiac Surgery: Two studies of different samples from the Multicenter Study of Perioperative Ischemia [39, 40] reported the prevalence of alcohol misuse, defined as a history of heavy drinking or hospitalization for alcoholism or withdrawal, of 9.9% and 9.5% respectively.

Surgical Specialties. Moore [29] defined alcohol abuse as a CAGE ≥ 2 or a SMAST ≥ 5 and reported a wide range of prevalence rates across surgical subspecialties, with the highest (43%) in otolaryngology surgeries and the lowest (14%) in urological surgeries. In another study, the prevalence of cur-

rent drinking and screening positive on the CAGE (>2) among vascular/thoracic surgical patients admitted to an ICU post-operatively was 9.7% [30].

Specific Surgical Procedures

Head and Neck Surgeries. Patients undergoing surgery for head and neck tumors were the most commonly studied surgical subspecialty, likely due to the strong association between alcohol use and development of these tumors. In a sample of patients undergoing major surgery for head and neck cancer, 49.2% of patients drank more than 2 drinks per day [32], while in another study 48% of head and neck cancer patients drank more than 6 drinks per week [33]. Robbins [31] categorized head and neck cancer patients according to their history of alcohol use (none, mild, moderate, severe based on unstated criteria) and found 49.5% to have histories of moderate or severe misuse. Pelczar [41] found 33% of head and neck cancer patients had a history of alcohol abuse. Oliver [45] found 74% of patients with oral squamous cell carcinoma had a history of daily alcohol use (not necessarily misuse). Similarly, Karl [44] found that regular alcohol use (not necessarily misuse) reported by 82% of transthoracic esophagogastrectomy patients. One study of patients undergoing reconstructive surgery related to head and neck cancer reported that 22.6% had a history of heavy alcohol use [42].

Orthopedic surgeries. Among patients undergoing bilateral knee replacement, 27.5% reported drinking > 3 drinks per week [36]. Among patients with injuries resulting in surgical repair of the mandible, 52% of the injuries were judged to be alcohol related based on medical record reviews [34].

Pulmonary surgeries. A study of patients undergoing surgery for lung cancer found that 32.7% of patients with resectable disease had one of several criteria for alcohol misuse recorded in the medical record: CAGE ≥ 2 or ≥ 5 drinks per day or meeting DSM IV criteria for an alcohol use disorder [48]. Canver [47] found that 29.1% of lung cancer resection patients drank more than 2 drinks per day pre-operatively.

Other Procedures: The reported prevalence rates of current alcohol use among surgical patients over 70 years old requiring free tissue transfer at Sloan Kettering was 20.3% [35]. Among patients requiring surgery for life threatening gastro-duodenal hemorrhage, 14.1% had a medical record documentation of a history of heavy drinking [38]. In a sample of patients with life-threatening intra-abdominal infections requiring laparotomy, 20.7% had a history of alcohol abuse [49].

Associations Between Alcohol Use or Misuse and Surgical Outcomes

Nineteen studies reported associations between pre-operative alcohol measures and post-operative outcomes and/or complications (Table 2), 14 of which also presented results on prevalence reported above.

Overall Post-operative Complications. Five studies examined the relationship between alcohol use or misuse and the occurrence of any post-operative complications, and 4 found significant positive associations [34, 35, 37, 41], with odds ratios ranging from 1.4 for patients who drank > 2 drinks per day in the 2 weeks before surgery undergoing radical cystectomy in 123 VA hospitals [37] to 3.5 among patients with mandible fractures attributed to alcohol use [34].

Table 1. Prevalence of Alcohol Use and Misuse in US Surgical Samples

Author, Year	Setting (Sample)	Alcohol Measure (Source Alcohol Data)	Total N	Prevalence %
Major Non-Cardiac Surgery				
Marcantonio 1994 [27]	BWH (General, orthopedic, and gynecology pts with post-op delirium)	“Do you have a current problem drinking too much alcohol?” (Research data collection)	91	7.7
Khuri 1995 [23]	44 VAs (NSQIP)	> 2 drinks/day (d/d) (Med record review)	83,958	15.2
Arozullah 2001 [22]	100 VAs (NSQIP)	> 2 d/d past 2 weeks (Med record review)	160,805	11.2
Leung 2005 [25]	UCSF (> 65 years)	> 2 d/d (Research interview; record review)	219	9.6
Major Cardiac Surgery				
Roach 1996 [39]	24 US medical centers, MCSPI (elective CABG)	History of heavy drinking, hospitalization for alcoholism, or alcohol withdrawal. (Source not determined)	2,108	9.8
Wolman 1999 [40]	24 US medical centers, MCSPI (CABG plus intracardiac procedure)	History of heavy drinking, hospitalization for alcoholism, or alcohol withdrawal. (Source not determined)	273	9.5
Surgical Subspecialties				
Moore 1989 [29]	Johns Hopkins Hospital (Inpatients on specific surgery services - not detox/short stay)	CAGE \geq 2 or SMAST \geq 5 (Research interview)	Obstetrics 556 Gynecology 242 General 179 Orthopedics 71 35 Urology 40 Otolaryngology 67 Cardiac 55 Neurosurgery 16	12.4 12.4 21 28 14 43 24 16
Maxson 1999 [30]	Mayo Clinic (Vascular/thoracic and post-op ICU)	CAGE \geq 2 and drinks. (Research interview)	321	9.7
Specific Surgical Procedures				
Kim 1974 [38]	Elmhurst City Hospital (Surgery for gastroduodenal hemorrhage)	History of heavy drinking (Med record review)	135	14.1
Canver 1998 [47]	William S. Middleton VA (Lung cancer resection)	> 2 d/d (Med record review)	79	29.1
Furr 2006 [34]	U Miss (Mandible fx)	Alcohol assoc. injury (Med record review)	271	52.0
Howard 2005 [35]	Sloan Kettering (> 70 years, free tissue transfers)	Alcohol use (Med record review)	197	20.3
Paull 2005 [48]	Single VA (Lung cancer)	CAGE \geq 2, \geq 5 d/d, or AUD (Med record review)	55	32.7
Oliver 1996 [45]	Methodist Hosp, Houston (oral SCC patients)	Daily alcohol use (Surgical log books)	92	74
Robbins 1990 [31]	MD Anderson (H&N cancer)	Hx Mild alcohol use* Hx Mod alcohol use* Hx Heavy alcohol use*	400	20 24 25.5
Colangelo 1999 [33]	Multi-center (H&N cancer)	>6 drinks/week Previously, no longer Currently (Research interview)	150	27 48
Pelczar 1993 [41]	Arthur G. James (Mj H&N cancer)	Current or previous alcohol abuse: Hx, clinical assess, or CAGE \geq 2 (research evaluation)	119	33.0
Weed 1995 [32]	Arthur G. James (Mj H&N cancer)	> 2 d/d (Researcher)	132	49.2
Shindo 2000 [42]	USC & UI (Reconstruct of H&N cancer)	Heavy alcohol use (Med record review)	53	22.6
Williams-Russo 1992 [36]	Orthopedic hosp (Bilateral TKA)	>3 drinks/week (Standardized clinician pre-op assessment)	51	27.5
Pine 1983 [49]	UW Hosp (Laparotomy for intra-abdominal infection)	“Alcoholism”	106	20.7
Karl 2000 [44]	Moffitt Cancer Center (Transthoracic esophagectomy)	Regular alcohol use (Research data collection)	143	82.5

* Measurement method not stated.

Abbreviations: VA = Veterans Affairs Medical Center; Med record review = Medical record review; d/d= drinks per day; CAGE = 4 item screening questionnaire for alcohol use disorders; SMAST= Short Michigan Alcohol Screening Test; fx= fracture; AUD = DSM-IV alcohol use disorders; H&N cancer = patients with resectable head and neck cancers; Mj H&N= Head and neck cancers with surgery > 2 hrs; TKA= total knee arthroplasty; MD Anderson =MD Anderson Cancer Center; UNC=University of North Carolina; U Miss= University of Mississippi; Sloan Kettering=Memorial Sloan-Kettering Cancer Center; Arthur G. James = Arthur G. James Cancer Hospital and Research Institute; MCSPI=Multicenter Study of Perioperative Ischemia; UCSF=University of California, San Francisco; USC=University of Southern California; UI=University of Iowa; Moffitt Cancer Center=H. Lee Moffitt Cancer Center & Research Institute; SCC=squamous cell carcinoma; UW=University of Washington; BWH = Brigham and Women’s Hospital, Boston MA; “Alcoholism” = diagnosis of “alcohol abuse” and: multiple admissions to inpatient treatment facility or multiple ER admissions with high blood alcohol levels or hepatitis pancreatitis, portal hypertension, varices, or cirrhosis.

Table 2. Association Between Alcohol Use and Misuse and Surgical Outcomes in US Studies

Author, Year	Setting (Surgical Sample, Total N)	Alcohol Measure (Source of Alcohol Data)	Outcome (Outcome Prevalence in Alcohol Groups or Total Population)	Association Alcohol Measure & Outcome (95%CI)
Major Non-cardiac Surgery				
Khuri 2005 [24]	120 VAs (NSQIP)	2 d/d, past 2 weeks (Med record review)	Death in 30 d Post-op	HR 1.1 (1.0 – 1.1)
Arozullah 2001 [22]	100 VAs (NSQIP)	2 d/d, past 2 weeks (Med record review)	Pneumonia (Alc+= 1.9%; Alc-= 1.5%)	OR 1.24 (1.08 – 1.42)
Litaker 2001 [26]	Cleveland Clinic (≥ 50 yo; N=500)	“Has Alcohol negatively affected health?” (Pre-op research eval.)	Post-op delirium (Total. 11.4%)	Adj. OR 6.5 (1.5, 28.1)
Marcantonio 1998 [28]	BWH (≥ 50 yo; N=1341)	Hx alcohol abuse* (Pre-op research eval.)	Post-op delirium (Total 9.0%)	OR 2.8 (1.2-6.3)
Major Cardiac Surgery				
Roach 1996 [39]	24 US medical centers, MCSPI (Elective CABG, N=2108)	History of heavy drinking, hospitalization for alcoholism, or alcohol withdrawal. (Source not determined)	Cerebral events: Type I (Alc+=5.6%; Alc-=3.0%), Type II (Alc+=5.6%; Alc-=2.8%)	Type I: not sig Type II: Adj OR 2.64 (1.27, 5.47)
Wolman 1999 [40]	24 US medical centers, MCSPI (CABG plus intracardiac procedure; n = 273)	History of heavy drinking, hospitalization for alcoholism, or alcohol withdrawal. (Source not determined)	Cerebral events: Type I (Alc+=0%; Alc-=9.9%), Type II (Alc+=19.2%; Alc-=6.7%)	Type I: not sig Type II: Adj OR 6.4 (1.4, 29.0)
Surgical Subspecialties				
Maxson 1999 [30]	Mayo Clinic (Vascular & Thoracic and post-op ICU; N=321)	CAGE ≥ 2 and drinks (Research interview)	Peri-op Complication (Alc+= 9.7%; Alc= 11.0%) Readmission ICU (Alc+= 19.4%; Alc= 7.9%)	OR 0.86 (0.25, 3.00) OR 2.79 (1.04, 7.48)
Klekamp 1999 [43]	Vanderbilt University (Spinal surgeries, N=70)	Alcohol abuse (Med record review)	Spinal wound infection (Alc+=100.0%; Alc-=44.4%)	Yates corrected Chi-square 5.71, p=.011
Specific Surgical Procedures				
Kim 1974 [38]	ECH (Life threatening gastroduodenal hemorrhage, N=135)	History of heavy drinking (Med record review)	Death (Alc+=47.4%; Alc-=20.7%)	RR 2.29 (1.27, 4.14)
Furr 2006 [34]	U Miss (Mandible fx; N=271)	Injury 2° alcohol (Med record review)	Complications (Alc+= 9.9%; Alc= 3.1%)	OR 3.47 (1.11, 10.84)
Howard 2005 [35]	Sloan Kettering (>70 yo, free tissue transfers; N=197)	Alcohol use (Med record review)	Overall complications	RR 3.4 (1.6 – 7.1)
Robbins 1990 [31]	MD Anderson (H&N cancer; N=400)	Hx Mild alcohol use* Hx Mod alcohol use* Hx Heavy alcohol use*	Wound infection (Mild 11.3%; Moderate 28.1%; Heavy 24.5 %)	ORs 1.37 (0.52, 3.62) 4.22 (1.87, 9.53) 3.50 (1.54, 7.93)
Pelczar 1993 [41]	Arthur G. James (Mj H&N cancer, N=119)	Current or previous alcohol abuse: Hx, clinical assess, or CAGE≥2 (Research evaluation)	Med complications (Total 24%) Wound infection (Total 11%)	Alcohol abuse had more med complications (p<.05) but not wound infection
Shindo 2000 [42]	USC & UI (Osteocutaneous flap reconstruct of H&N cancer, N=53)	Heavy alcohol use (Med record review)	Major and minor wound infections (Alc+=41.7%; Alc-=24.4%)	RR 1.71 (0.72, 4.04)
Weed 1995 [32]	Arthur G. James (Mj H&N cancer; N=132)	> 2 d/d (Researcher)	Post-op delirium (Alc+= 23.1%; Alc= 10.4%)	OR 2.57 (0.97, 6.8)
Williams-Russo 1992 [36]	Orthopedic hosp (Bilateral TKA; N=51)	>3 drinks/week (Standardized clinician pre-op assessment)	Post-op delirium (Alc+= 64.3%; Alc= 32.4%)	OR 3.75 (1.0 – 13.7)

(Table 2) contd.....

Author, Year	Setting (Surgical Sample, Total N)	Alcohol Measure (Source of Alcohol Data)	Outcome (Outcome Prevalence in Alcohol Groups or Total Population)	Association Alcohol Measure & Outcome (95%CI)
Hollenbeck 2005 [37]	123 VAs (NSQIP-cystectomy; N=2,538)	2 d/d, past 2 weeks (Med record review)	≥ 1 Post-op complication (Alc+= 33.9%; Alc-= 30.1%) Wound Infection (only OR reported)	OR 1.4 (1.1 – 1.9) OR 0.5 (0.2-0.9)
Karl 2000 [44]	Moffitt Cancer Center (Transthoracic esophagogastrectomy N=143)	Regular alcohol use (Research data collection)	Death (Total 2.1%); Complications (Total 29%).	No significant association between alcohol use (n=118) and no alcohol use (n=25)
Pine 1983 [49]	UW Hosp (Laparotomy for intra-abdominal infection; N=106)	“Alcoholism”	Mortality (Alc+=45%; Alc-=15.1%) Post-op shock and lung malfunction	RR 3.47 (1.70, 7.10) P<0.0001

*Measurement method not stated.

Abbreviations: VA = Veterans Affairs Medical Center; BWH = Brigham and Women’s Hospital, Boston MA; Med record review or record review = Medical record review; d/d= drinks per day; CAGE = 4 item screening questionnaire for alcohol use disorders; fx= fracture; AUD = DSM-IV alcohol use disorders; ECH = Elmhurst City Hospital ; H&N cancer = patients with resectable head and neck cancers; Mj H&N= Head and neck cancer patients with surgery lasting > 2 hrs; TKA= total knee arthroplasty; MD Anderson =MD Anderson Cancer Center; UNC=University of North Carolina; U Miss= University of Mississippi; Sloan Kettering=Memorial Sloan-Kettering Cancer Center; Arthur G. James = Arthur G. James Cancer Hospital and Research Institute.; Type I cerebral events=death due to stroke, TIA, non-fatal stroke, stupor, coma; Type II cerebral events=intellectual decline, agitation, disorientation, memory deficits; Moffitt Cancer Center=H. Lee Moffitt Cancer Center & Research Institute; MCSPI=Multicenter Study of Perioperative Ischemia.

Post-operative Death. Four studies examined the relationship between alcohol use or misuse and post-operative death. More stringent definitions of alcohol misuse tended to result in larger associations. Karl [44] found regular alcohol use (not necessarily misuse) reported by 82% of transthoracic esophagogastrectomy patients to be unrelated to post-operative death. Khuri [24] found pre-operative drinking over 2 drinks per day in 2 pre-operative weeks to be associated with death in the 30 post-operative days (HR = 1.1). Kim [38] found a history of heavy drinking to be associated with post-operative death (RR = 2.29) in a sample of patients requiring surgery for life threatening gastroduodenal hemorrhage. Finally, Pine [49] found patients requiring laparotomy for life-threatening intra-abdominal infections who met criteria for “alcoholism” to be at significantly increased risk of death (RR = 3.47).

Post-operative Delirium. Overall, surgical patients who consumed more alcohol were at significantly greater risk of post-operative delirium. Despite variation in sample characteristics and alcohol assessment instruments, alcohol use or misuse was significantly associated with a 2 to 6 fold increase in the odds of post-operative delirium in three of four studies [26, 28, 36]. The other showed a trend toward an association [32].

Post-operative Cerebral Events. Two studies [39, 40] reported the associations between a history of alcohol abuse and cerebral events in cardiac surgery patients. Both studies of patients undergoing CABG (elective or associated with an intra-cardiac procedure), found that a history of alcohol abuse was significantly associated with Type II cerebral events (i.e., intellectual decline, agitation, disorientation, memory deficits), but not Type I cerebral events (i.e., death due to stroke, TIA, non-fatal stroke, stupor, coma).

Wound Infections. Five studies [31, 37, 41-43] evaluated associations between pre-operative alcohol use or misuse and surgical wound infection. Robbins [31] found patients

with moderate and severe alcohol misuse had significantly greater odds of post-operative wound infections (OR’s = 4.22 and 3.50 respectively). Klekamp [43] found a similar positive association in a sample of spinal surgery patients. However, two studies [41, 42] found no association between pre-operative alcohol use and surgical wound infection and another [37] found that patients who drank 2 or more drinks daily in the pre-operative two weeks were significantly less likely to have wound infections (OR = 0.50).

Other Post-op Complications. Several other complications were linked to preoperative alcohol use or misuse. Patients drinking more than 2 drinks per day in the 2 weeks prior to surgery were at increased risk for post-operative pneumonia (OR = 1.24) [22]. Among vascular and thoracic surgery patients who were initially managed in intensive care (ICU), screening positive for alcohol use disorders was associated with readmission to the ICU (OR = 2.8), but not perioperative complications [30].

Strengths and Limitations of Identified Studies

All identified studies, except those which used the VA’s NSQIP and the Multi-Center Study of Perioperative Ischemia, sampled patients from a single site, and most were tertiary medical centers. Sampling strategies were often not described, but most studies, with the exception of those using the VA’s NSQIP, were or appeared to be consecutive case series. Per our criteria, studies were excluded if they described use of an alcohol measure as one of many measures evaluated but did not present any alcohol-related results [50].

Measures of alcohol use or misuse varied considerably across the studies and less than 25% of studies used standardized interviews or validated screening tests, such as the Alcohol Use Disorders Identification Test (AUDIT), a screening test for the entire spectrum of alcohol misuse, or the CAGE, a 4-item alcohol misuse screen derived from the diagnostic questions that identify alcohol use disorders ever in a patient’s life (Have you ever felt you should Cut down

on your drinking? Have people Annoyed you by criticizing your drinking? Have you ever felt Guilty about your drinking? Have you ever had a drink first thing in the morning [Eye-opener]?). While 12 studies used assessments based on interviews or self-report questionnaires, 10 were based on clinical information abstracted from the medical record, and four studies did not state the source of the alcohol data. Measures varied from dichotomous measures of lifetime or current alcohol use [23, 24, 35], screening questionnaires for lifetime alcohol use disorders such as the CAGE and Short Michigan Alcoholism Screening Test (SMAST) [29, 48], categorization based on drinking over 2 or 3 drinks per day or over 6 drinks a week, judgments that alcohol use was associated with an injury [34], DSM criteria for alcohol use disorders or binge drinking [48], and self-reported history of alcohol abuse [28] or alcohol use impacting health [26]. A major limitation of studies identified was the lack of description of how alcohol use/misuse was assessed and the timeframe of the alcohol measure (Tables 1 and 2), so that it was often unclear if patients who were categorized as at-risk due to drinking continued to drink at the time of surgery. No study used a measure that specifically assessed whether patients consumed over 60 grams of alcohol or more than 4 drinks a day in the pre-operative period, the level of drinking most strongly associated with post-operative complications in European studies [1-14].

Measures of the post-operative outcomes evaluated by studies varied extensively. Delirium was the most common specific post-operative complication evaluated; others included pneumonia, wound infections and readmission to the ICU. Several studies evaluated overall post-operative complications, but none specifically evaluated cardiovascular or bleeding complications, which have been found to be associated with alcohol misuse in studies outside the US. None of the reviewed studies reported blinding of outcome assessors to pre-operative alcohol status, although for VA NSQIP studies standardized outcome measures were collected for quality improvement, so it is less likely that the abstractor's knowledge of a patient's drinking status biased assessment of outcomes.

DISCUSSION

This review reveals several shortcomings in current knowledge of the prevalence and implications of alcohol misuse among US surgical patients. In our standardized review of the US literature, we found no study that measured the prevalence of drinking over 60 grams of alcohol per day (about 4 drinks daily) in surgical patients, the level of alcohol consumption that has typically been associated with post-operative complications in European studies. Moreover, the alcohol measures used were often nonstandard and sometimes not described. Due to the lack of specified timeframe it was often not possible to know whether patients who were in the alcohol misuse group continued to drink at the time of surgery. With the exception of studies in the VA and the Multicenter Study of Peri-operative Ischemia, all identified studies of alcohol misuse in US surgical populations included patients from a single site, many of which were tertiary academic facilities, limiting generalizability. Almost nothing is known about differences in the prevalence of alcohol misuse or its association with post-operative complications across age, gender, or race/ethnic groups in US surgical

samples. No study has compared the prevalence of alcohol misuse or its association with post-operative complications among patients who smoke and those who do not. Many studies of surgical outcomes associated with alcohol use or misuse lacked blinded assessment of outcomes.

Direct comparison of findings of this literature to the extensive European research on alcohol misuse in surgical populations is not possible due to differing alcohol measures used. German and Danish studies have typically conducted detailed assessments of patients' drinking to identify those who drank over 60 grams of alcohol daily [4-7, 11-13, 51, 52], or those who drank over 60 grams of alcohol daily and screened positive on standardized screening questionnaires such as the MAST [53] or CAGE [15, 16, 54, 55]. A large Spanish study of hospital-acquired infections used a structured questionnaire to assess alcohol consumption above 72 grams per day [56] and a recent German study showed that the 10-item AUDIT identified a much higher prevalence of alcohol misuse than anesthesiologists who usually asked nonstandard questions about alcohol consumption [57].

Nevertheless we can draw several preliminary conclusions about the prevalence of alcohol use and misuse in US surgical samples. The prevalence of alcohol use and misuse appears to be higher in major otolaryngology surgeries (mostly for cancer and injuries: 30-88.5%) [31-34, 41, 42, 44, 45], vascular, and thoracic surgeries (cancer resections: 29-33%)[47, 48] likely reflecting the association of alcohol misuse with head and neck tumors and smoking which increases the risk of head, neck, and lung cancers. In the remaining studies of other surgery types that reported prevalence, alcohol use and misuse ranged from 7.7-28%. This wide range reflects both diverse samples and the variety of alcohol measures used (e.g. ranging from any current use to lifetime alcohol use disorders).

Several conclusions can also be drawn about the association of alcohol misuse and post-operative complications in US surgical populations despite limitations noted above. The 19 studies examining the associations between pre-operative alcohol measures and post-operative outcomes suggest positive associations between alcohol misuse and risk for post-operative delirium, pneumonia, cognitive decline, overall complications, and death from complications.

This review has two important limitations. First, our results reflect publication bias in the literature reviewed. We identified a number of studies that included alcohol measures but did not report prevalence or association between alcohol use or misuse and complications. It is likely that these studies either found low rates of alcohol use/misuse or no association between alcohol measures and surgical complications. Second, although we made every attempt to identify all studies that met our inclusion criteria, many studies of surgical outcomes include multiple pre-operative measures, and it is therefore likely that we missed one or more surgical studies that reported on alcohol use or misuse, and that in some studies the association between alcohol and post-operative outcomes could have been spurious due to the large number of risk factors being evaluated.

Nevertheless, this review has several important implications. Evidence from Europe suggests that 30 days of pre-operative abstinence can significantly reduce post-operative

complications [1]. This review suggests that up to 50% of US surgery patients may misuse alcohol and that alcohol misuse is associated with surgical complications in US samples. Although more research is needed on the optimal approaches to identifying patients with alcohol misuse in surgical settings, differences in the prevalence across demographic subgroups of patients and types of surgery, and the association between alcohol misuse and post-operative complications, the preliminary evidence presented here combined with evidence from Denmark on the benefits of pre-operative abstinence [1], suggests a possible benefit for pre-operative alcohol screening. To be maximally effective, such screening would need to occur at least 4 weeks preoperatively [58] and would require clinical systems to address positive screens.

A second and related implication is that there is no standard approach to assessing alcohol use and misuse pre-operatively. The measures used to assess alcohol misuse in the studies reviewed here varied greatly. The CAGE and SMAST screening questionnaires assess whether patients have ever experienced problems due to drinking. These measures are good instruments for identifying lifetime alcohol use disorders, but may be less sensitive for identifying drinking over 60 grams (~4 drinks) daily, suggested to be the threshold for post-operative complications in studies in other countries.

US surgeons, anesthesiologists and referring clinicians wishing to assess pre-operative alcohol-related risk could benefit from routine use of a brief, valid screen to identify patients at risk for alcohol-related surgical complications [57]. Without routine screening with a validated alcohol screening questionnaire, providers forget to ask and/or they assess typical or average alcohol consumption which is often under-reported by patients [57]. An extensive body of research across clinical settings has demonstrated the need to conduct routine alcohol screening with a validated questionnaire in order to identify the majority of patients with alcohol misuse [59]. While a number of validated standardized screening approaches have been developed and validated, those that are briefest are likely most practical [20, 60, 61]. Eventually it would aid research comparisons across sites and countries if a standard validated alcohol screening measure were used in surgical settings nationwide.

Additional research is needed to understand the prevalence of alcohol misuse and its association with post-op complications in US surgical populations. Future studies should employ validated screening tests for alcohol misuse (e.g. AUDIT-C [58] or frequency of drinking ≥ 4 drinks daily) and should seek to include larger samples and blinded assessment of surgical outcomes. Furthermore, future studies need to examine whether the association between alcohol misuse and surgical complications is modified by other factors. Is alcohol misuse a more potent risk factor for complications in certain subgroups (e.g., defined by age, gender, or smoking status)? Finally, additional research will be needed to determine effective approaches to reducing alcohol-related surgical complications among patients who screen positive for alcohol misuse.

Summary of Tentative Clinical Recommendations

With the above caveats in mind, we offer the following tentative recommendations based on the European research

on alcohol misuse and surgical outcomes and the extensive literature on the efficacy of brief interventions for alcohol misuse. Surgical patients should be screened pre-operatively using a valid measure of alcohol misuse, such as the AUDIT-C or a question about episodic heavy drinking [60]. If possible, screening should be 4 weeks prior to surgery so that high risk patients can be advised to abstain for the month pre-op [1]. Even if screening 4 weeks pre-operatively is not possible, patients may benefit from brief interventions addressing their alcohol misuse. An Australian study of brief intervention at least 7 days prior to surgery (mean: 10 days) did not improve operative outcomes [62], but pre-operative patient counseling could have benefits nevertheless, since brief interventions have been shown to decrease drinking [63]. Efficacious brief interventions include advice to reduce drinking below recommended limits and feedback linking alcohol consumption to health and surgical outcomes. U.S. recommended limits are no more than 7 drinks per week for women and 14 drinks per week for men and no more than 3 drinks on an occasion for women and 4 drinks on an occasion for men [20]. Patients with severe alcohol misuse likely to have alcohol dependence should be offered referral to a treatment program for alcohol abuse and dependence and/or advised to abstain pre-operatively and offered assistance with management of alcohol withdrawal if necessary. In addition, surgical patients who screen positive for alcohol misuse should be managed expectantly for post-operative alcohol withdrawal [64].

AUTHORS' CONTRIBUTIONS

AHSH reviewed and abstracted studies and prepared the manuscript. MSF conducted the search, reviewed and abstracted studies, and contributed to the preparation of the manuscript. AFD conducted the search, reviewed studies, and contributed to the preparation of the manuscript. KAB conceptualized the study and contributed to the preparation of the manuscript. All authors reached consensus on discrepancies between 2 abstractors' extracted data, and read and approved the final manuscript.

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