

# Citation

Caplan RA: Liability Arising from Anesthesia Gas Delivery Equipment. *ASA Newsletter* 62(6):7-9, 1998.

## Full Text

Almost every piece of medical equipment carries some potential for misuse or failure. Gas delivery devices are a particular concern in anesthesia because they exhibit features that may predispose to critical events. These include the need for multiple connections, the use of complex mechanical and electrical components, and variations in manufacture and design. We recently used the American Society of Anesthesiologists (ASA) Closed Claims Project database to conduct an in-depth analysis of adverse outcomes associated with the use of anesthesia gas delivery devices.<sup>1</sup> Our goal was to identify patterns of causation and strategies for prevention that might not be evident to practitioners who encounter these adverse outcomes as isolated events.

## Key Findings

Gas delivery equipment accounted for 72 of 3,791 claims (2 percent) in the ASA Closed Claims Project database.<sup>1</sup> The most common adverse outcomes were death (47 percent) and brain damage (29 percent) [Table 1]. The breathing circuit was the most common source of injury, accounting for 39 percent of gas delivery claims. Vaporizers, ventilators and oxygen supply tanks or lines together accounted for 49 percent of these claims. Events associated with the anesthesia machine itself were comparatively rare (7 percent). Almost all adverse outcomes occurred in the operating room (86 percent). The remaining events took place in the postanesthesia care unit (8 percent) or intensive care unit (6 percent). Claims involving endotracheal tubes and masks were not included in this study, as they have been analyzed separately (see Reference 1).

**Table 1**

<b>Adverse Outcomes Associated With Gas Delivery Equipment</b>							
<b>Equipment Group</b>	<b>OUTCOME</b>						
	<b>Cases</b>	<b>Death</b>	<b>Brain Damage</b>	<b>Awareness /Fright</b>	<b>Recovery Delayed</b>	<b>Tracheotomy Scar</b>	<b>Pneumothorax</b>
Breathing circuit	28	10	10	1	5	1	1
Vaporizer	15	7	3	5	0	0	0
Ventilator	12	7	5	0	0	0	0
Supply tank or line	8	6	2	0	0	0	0
Anesthesia machine	5	3	0	1	0	1	0
Supplement O <sub>2</sub> tubing	4	1	1	0	0	0	2
<b>TOTAL</b>	<b>72 (100%)</b>	<b>34 (47%)</b>	<b>21 (29%)</b>	<b>7 (10%)</b>	<b>5 (7%)</b>	<b>2 (3%)</b>	<b>3 (4%)</b>

Equipment misuse was three times more frequent than equipment failure (75 percent versus 24 percent) [Table 2]. (*Misuse* was used to characterize claims in which the injury originated from human fault or error associated with the preparation, maintenance or deployment of a medical device; *failure* was used to characterize claims in which the device appeared to malfunction unexpectedly, despite routine maintenance and previous uneventful use.)

**Table 2**

<b>Misuse and Failure of Gas Delivery Equipment</b>			
<b>Equipment Group</b>	<b>Claims Characterized By</b>		
	<b>Misuse</b>	<b>Failure</b>	<b>Uncertain</b>
Breathing circuit (n=28)	26	2	0
Vaporizer (n=15)	7	8	0
Ventilator (n=12)	8	3	1
Supply tanks or lines (n=8)	7	1	0
Anesthesia machine (n=5)	2	3	0
Supplemental O <sub>2</sub> tubing (n=4)	4	0	0
<b>TOTAL (n=72)</b>	<b>54 (75%)</b>	<b>17 (24%)</b>	<b>1 (1%)</b>

In 70 percent of claims involving misuse, the fault or error arose directly and almost exclusively from actions of the primary anesthesia provider. In the remaining 30 percent of claims, misuse arose, at least in part, from contributory actions of ancillary personnel. Some examples of contributory actions include the incorrect installation of gas lines or tanks by construction workers, engineers or service technicians (7 cases) or the creation of a direct attachment between an endotracheal tube and a 50-psi oxygen source by nursing personnel (4 cases).

Misconnects and disconnects of the breathing circuit accounted for slightly more than two-thirds of claims (25/72; 35 percent). (A *misconnect* was defined as a nonfunctional and unconventional configuration of breathing circuit components or attachments; a *disconnect* was defined as the loss of attachment or continuity in a breathing circuit that was initially configured in a functional and conventional manner.)

Misconnects were slightly more frequent than disconnects (19 percent versus 15 percent of all gas delivery claims). The three most frequently specified sites for disconnects and misconnects were: 1) the junction between the breathing circuit and the gas delivery outlet of the ventilator (9/25; 36 percent); 2) the junction between the distal end of the breathing circuit and the endotracheal tube (4/25; 16 percent); and 3) a location on the inspiratory limb of the breathing circuit that allowed the interposition of a positive end-expiratory pressure valve (3/25; 12 percent).

Most of the gas delivery claims resulted from events that took place in the 1980s (49/72; 68 percent), with occurrence dates ranging from 1962 to 1991. Of note, claims involving anesthesia machines, ventilators and oxygen supply lines or tanks all took place before 1990, while claims involving breathing circuits, vaporizers and supplemental oxygen tubing continued to occur in the 1990s.

More than three-fourths of the gas delivery claims (56/72; 78 percent) were considered preventable with the use or better use of monitoring. Half of the claims (38/72; 53 percent) were considered preventable if a pulse oximeter, capnograph or both of these two monitors had been used. Preventive roles were also identified for other monitors, such as the anesthetic agent analyzer (17 percent), oxygen analyzer (12 percent), airway pressure alarm (10 percent) and precordial or esophageal stethoscope (1 percent). In 18 percent of the claims, a monitor or alarm that could have played a preventive

role was physically present but was either broken, turned off or in a disabled mode.

Claims that were not considered preventable with better monitoring (16/72; 22 percent) typically involved situations in which a critical incident progressed rapidly to the point of an injurious physiologic process. Some examples include barotrauma produced by attaching an endotracheal tube directly to a 50-psi source of oxygen or cardiovascular depression produced by spilling a liquid inhalational agent into the breathing circuit.

Payment was received in 76 percent of gas delivery claims. The median payment for settlement or jury award was \$306,000, with a payment range of \$542 to \$6,337,000. This is comparable to payments for other adverse respiratory events in the Closed Claims Project database (median \$230,000; range \$390 to \$6,300,000), but significantly higher than payments for nonrespiratory events (median \$50,000; range \$15 to \$23,000,000;  $p < 0.01$  for payment distributions).

## Commentary

During the past two decades, large scale surveys of anesthetic outcome have identified gas delivery equipment as a small but recurrent cause of serious injury.<sup>2-8</sup> These studies attribute approximately 1 percent to 5 percent of anesthesia-related death and brain damage to problems with gas delivery equipment. The ASA Closed Claims Project presents a similar picture, with gas delivery equipment accounting for 3 percent of claims for death and 5 percent of claims for brain damage.

Gas delivery equipment plays a prominent role in critical incident studies, often contributing to more than 20 percent of all reported events.<sup>9-15</sup> In contrast, claims involving gas delivery equipment account for only 2 percent (72/3,791) of the overall ASA Closed Claims Project database. This difference may arise, at least in part, from the fact that critical incidents are events that have the potential to cause injury and many critical incidents are detected and remedied before an identifiable injury occurs.

Anesthesia gas delivery depends on the use of devices with multiple connections and moving parts. On this basis, one might expect equipment failure to play a particularly important role. Instead, the frequency of equipment misuse was three times greater than equipment failure. This finding is consistent with previous studies that have emphasized the prominent role of human error in equipment-related critical incidents and adverse outcomes.<sup>9-12</sup>

Of note, the breathing circuit made the single largest contribution to the misuse of gas delivery equipment (26 of 54 misuse claims; 48 percent). Furthermore, almost all adverse outcomes involving the breathing circuit arose from either a misconnect or disconnect (25/28; 89 percent). These findings suggest that a fundamental re-evaluation of the breathing circuit from a "human factors" perspective may be a particularly effective strategy for patient safety efforts.

An interesting aspect of the present study was the observation that ancillary personnel make an important contribution to the anesthesiologist's liability. Misuse of equipment by nonanesthesiologists contributed to patient injury in one-fifth of all gas delivery claims. This finding suggests that preventive strategies and educational efforts need to extend beyond the simple conceptual boundaries of the operating room.

## Summary

Claims involving gas delivery equipment represent a small fraction of the ASA Closed Claims Project database. These claims are characterized by a high severity of injury, a high cost and a prominent role for equipment misuse. The breathing circuit represents the single largest source of gas delivery claims, and almost all of these claims arise from misconnects or disconnects.

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