Inhalational Anesthesia Gas Calculations: Billing issues and Outcome Measures

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My opinion

The most important component of anesthesia billing that is not accurately calculated is the costs of carrier gases and inhaled anesthetic agents. The volatile anesthetics contribute to almost 20% [1] of the anesthesia-related costs further emphasizing the need for their accurate measurements. These calculations are primarily hampered by the characteristic dynamic pattern of anesthetic agent usage in individual patients in different clinical circumstances. Moreover, variability of anesthetics usage may exist even when individual patients are repeatedly administered anesthetics [2] and this inter-patient and intra-patient variability contributes to significant variability in anesthetic gases calculations. The calculations have been made easy (though not perfect) with inspired and expired gas analyses of the various gas components including carrier gases and inhalational anesthetics.

In United States, almost all healthcare costs are paid by third party payors and there is difference between the actual facility bills for services, equipments and medications provided to the patients and the reimbursements made by the third party payors after their adjustments on the total bills (reimbursements after adjustments may be 10%-40% of the actual facility bills [3]). However the purview of our discussion is limited to the facility fees of inhalational anesthetic gases. There are various forms of billing for the inhalational anesthetic gases usage in operating rooms. As most hospitals are still not equipped with electronic anesthesia records (EARs), the most commonly used billing method is time-based model wherein gases (isoflurane, desflurane and sevoflurane) are billed as 15-minute incremental units. This billing model considers that patient was receiving inhalational anesthetics uniformly at 1-Minimum-Alveolar-Concentration (MAC) across the whole 15-minutes and during all such time-units. However, this may correspond to overbilling because 1-MAC of inhalational gases is not always required by every patient and is not always aimed by every anesthesia provider team. Contrarily, following the 15-minute incremental unit model may correspond to underbilling in some clinical scenarios like inhalational induction of anesthesia, laryngeal mask airway (LMA) anesthesia, mask general anesthesia and airway-lung surgeries which require higher amounts of gases (both carrier gases and inhalational anesthetics) to sustain the anesthetic state while compensating for significant anesthesia gas leaks across the various sites like around the poorly-sealed masks, around the poorly fitted LMA, and through exposed airway, pleura and lungs. Historically, in contrast to calculations of intravenous agents usage, the lack of uniform documentation for gas usage had been only hindered by the delay in uniform implementation of EARs and the lag in anesthesia delivery systems technology to effortlessly provide information about correct gas usage calculations.

The operation suites with functioning EARs may consider use of alternative billing method wherein gas usage can be calculated with formula based on constantly varying MAC multiplied with the time interval during which that particular MAC-value was recorded in the EARs. The data-trends recorded in EARs are at a minimum of one-minute intervals. Therefore, the billing formula will be: \[ \text{MAC-hours} = \text{MAC}_1 \times \text{Time (in minutes)}_1 + \text{MAC}_2 \times \text{Time (in minutes)}_2 + \text{MAC}_3 \times \text{Time (in minutes)}_3 + \ldots + \text{MAC}_n \times \text{Time (in minutes)}_n \]. This MAC-hours calculation is based on patient-end calculation wherein MAC calculation is standard algorithm-based inhalational anesthetics concentrations and carrier gases concentrations in the inspired and expired gas analyses. This MAC calculation may or may not be age-corrected depending on the Anesthesia Delivery Units. However, consequent MAC-hours calculation does not take into account the actual gas usage at the machine-end. For this reason, some machines like S/5™ Anesthesia Delivery Unit (GE Healthcare, Waukesha, Wisconsin, USA) have gas usage function [4] that when zeroed before the start of anesthesia, gives information about the amount of inhalational anesthetics used (isoflurane, desflurane and sevoflurane) in 5-ml increments and the amount of carrier gases used (oxygen, air and nitrous oxide) in one-liter increments.

The final method, similar to other described methods [5-8] and our minimal modification of the methods devised by Schwarz et al. [5] and Boldt et al. [6], can measure the amount of inhalational anesthetics down to 0.1-1 g depending on the accuracy of the precision weighing machines. Schwarz et al. [5] measured the
weights of bottles containing inhalational anesthetics as liquid. They performed these measurements before and after filling the vaporizers. Boldt et al. [6] had conducted the trial wherein they measured the vaporizers like Vapor 19.3 (isoflurane-sevoflurane) and TEC 6 (desflurane) that are usually fixed to the anesthesia machines and not as easily detachable. However with detachable cassette vaporizer systems like Aladin™ (GE Healthcare, Waukesha, Wisconsin, USA) becoming commonplace in most of the anesthesia workplaces, our modification precludes the use of weighing the liquid anesthetic bottles or older vaporizers and supports the weighing of cassette vaporizers before the initiation as well as after the cessation of inhalational anesthesia. Hence per our method, the inhalational anesthetics used in any case can be correctly measured (in ml) by dividing the net change in cassette vaporizer’s weight (in grams) during the anesthesia with the specific weight (in grams/ml) of inhalational anesthetic. Our method can only be used to calculate inhalational anesthetics; carrier gases usage cannot be calculated with our method. As we are only suggesting about measuring the easily detachable cassette vaporizer systems because we routinely detach and attach these cassette systems many times in a day for rapidly changing between the vaporizers as well as filling them with the anesthetic agents, the implied precision weighing machines are very small in size, shape and weight of their own and easily sits on front shelf of either anesthesia machines or anesthesia carts while measuring the weights of cassette vaporizers and can be easily stored inside any of their bottom shelves when not using for weighing the cassette vaporizers. Additionally, the calibration of precision weighing machine and documentation of these measurements take only couple of seconds that can be easily done as part of anesthesia readiness by the anesthesia providers. Integrity of vaporizers cannot be a concern with repeated measurements as these cassette systems are supposedly superior to other types of vaporizers because of their eased endurance in attach-detach-abilities. As checkout of cassette systems for leaks (part of electronic equipment anesthesia checklist) is routinely performed once in a day, it is less likely (though not completely guaranteed) that mounting-dismounting between multiple cases will induce increased incidences of missed leaks within the anesthesia delivery systems. To avoid costs of personnel injuries that may be sustained while mounting-dismounting non-cassette-based heavy vaporizers, we are limiting our purporting for precision weighing only cassette vaporizer systems and the operating rooms utilizing other types of vaporizers that are heavy in their own weights and cumbersome to attach-detach can utilize one of the other methods of calculating anesthetic gas usage.

The reasons for this discussion about the abovementioned four methods of cost measurements are multiple. Firstly, it appropriates the anesthesia drug bills’ ambiguity. For example, Medicare Average Sales Prices are limited by the absence of standard methods of calculations for anesthetic gases usage and therefore, the anesthetic gases are conspicuous by their absence in the Average Sales Price Drug Pricing Files [9] that already contain other anesthetic medication prices. Secondly, the hospital managements get the transparent quantifications to support their efforts to decrease the burden of costs incurred with costlier inhalational anesthetics (sevoflurane bills and desflurane bills are 4-6 times costlier than isoflurane bills because of similar differences in their purchase costs; the exact ratios for anesthesia billing are prerogative of hospitals who all depending on their inter-hospital research and individual calculations that may also include the costs of pharmacy procurement, maintenance and dispensing services, follow one-or-other personalized ratio conversions from purchase costs to billing costs). There have been few efforts already about the changes in anesthesia practice to reduce the inhalational anesthetics costs like by limiting the fresh gas flow [10-11] and preferential usage of isoflurane in inpatient long duration surgeries. However, the exact impact of these reductions in anesthetic gases costs will vary depending on the calculation accuracies of the methods used for assessing the inhalational anesthetic gas usage (total anesthetic bottles purchased or used over time [11] and anesthetic machine based cumulative calculations of fresh gas flows per minute [10]). Thirdly, as most anesthesia ventilators are driven by oxygen and there is often intermittent use of flush valve for emergency gas supply, the calculations of carrier gases by the gas usage function can make a significant difference for anesthesia cost calculations. Fourthly, with new wave of eco-friendly hospitals, the difference between the actual gas usage in operating rooms (as calculated by our method) and the actual wastage of liquid anesthetics (as calculated by the difference in monthly purchase orders for inhalational anesthetics as liquids and the actual gas usages through the month) can help hospitals’ eco-awareness campaigns to regulate the environmental burden incurred by the wasted inhalational anesthetics (both liquid and gaseous forms). Finally, similar to peri-operative outcomes correlation with correctly quantified intravenous agents (anesthetics, analgesics and muscle relaxants), the
exact calculations of the inhalational anesthetics can lead to peri-operative outcome analyses with more objectivity especially in relation to peri-operative hemodynamic stability and postoperative cognitive functions by investigating correlations between these patient outcome measures and the correctly calculated total amounts of inhalational anesthetics used perioperatively. Even though there may be arguments against the needs for adding these calculations that may be miniscule and insignificant with low fresh gas flows in our day-to-day anesthesia care services, we as the authors are confident that when the safety of inhalational anesthetic agents (both patients’ immediate hemodynamic as well as short-term and long-term cognitive safety, and environment’s greenhouse and global warming concerns) achieves momentum, the anesthesia providers in retrospect will recognize their astution in regards of appreciating that inhalational anesthetic agents easy and precise calculations were instituted in their medical documentation process just in the nick of time. Moreover, these safety concerns that may be related to actual total amounts of inhalational anesthetics used (toted for patients and the providers and city environments) and not only to MAC-hours used in patients, the eco-friendly hospitals will be deterred from achieving inflated compensations wherein patterns of wasteful high fresh gas flows that look promising avenue for increased billing of anesthetic gas usage costs, will actually harm their go-green image makeovers. Even though immediate patient safety concerns about variable extubation times and other physiological recovery characteristics [12-14] with different inhalational anesthetic agents add different parameters to actual cost calculations associated with the delivery of these agents, our propositions for precise gases’ amounts and their cost calculations are primarily focused to incite awareness and discussions about the under-privileged concerns for gas-amounts related patients’ long term cognitions and city atmosphere safety when exposed to scavenged and then vented inhalational anesthetic gases.

Conclusion

In summary, even though it looks apparent that anesthesia billing process will become more complex (again reimbursements are governed by altogether different perspectives and are prerogatives of the payors in United States, and we as the authors of this discussion are focusing only on billings which still are the prerogatives of the anesthesia service providers primarily the hospitals), it is high time for appropriate calculations of anesthesia gases to avoid issues of both underbilling as well as overbilling, and to integrate gas usage calculations based insight into perianesthesia quality assurance projects.

Reference(s)

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