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One-lung ventilation is well tolerated in dogs undergoing thoracoscopic surgery irrespective of device or side of lung blocked

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Objective
To report on placement and perioperative outcomes associated with one-lung ventilation (OLV) devices utilized in dogs undergoing thoracoscopic surgery.

Methods
This multi-institutional retrospective study included dogs undergoing OLV for elective thoracoscopic surgery between January 2013 and December 2023. Patient data, OLV technique, surgical and anesthetic complications, and perioperative blood gases were recorded. Success of OLV was defined as sustained collapse of the intended lung. Complications were graded from 1 (mild) to 5 (death or euthanasia).

Results
93 dogs (47 female, 46 male) were included. The median age was 9.5 years (range, 0.08 to 14.7 years) and median weight was 26.8 kg (range, 2.5 to 62.8 kg). Devices used for OLV included endobronchial blockers (n = 71), double-lumen tubes (15), selective intubation with an endotracheal tube (1), or unspecified (6). One-lung ventilation was successful in 90 dogs. Conversion to an open approach occurred in 23 cases and was secondary to complications of OLV in 4 cases. Grade 2 (moderate) and 3 (severe) hypercapnia were recorded in 62 of 93 dogs and 11 of 93 dogs, respectively. Grade 2 and 3 hypoxemia were recorded in 10 of 93 dogs and 6 of 93 dogs, respectively. Dogs with left bronchus blockade had significantly lower odds of grade 2 hypoxemia compared to dogs with right bronchus blockade.

Conclusions
OLV was successful in most cases. Intraoperative hypercapnia and hypoxemia were commonly reported, but rarely led to conversion and typically resolved postoperatively.

Clinical Relevance
OLV is a well-tolerated technique in dogs undergoing thoracoscopic procedures with excellent short-term outcomes.

Keywords: ventilation, thoracoscopy, pulmonary, bronchial blockade, minimally invasive surgery

One-lung ventilation (OLV) is a technique in which one lung is selectively ventilated while the other is collapsed. In veterinary medicine, this technique is primarily utilized in the setting of thoracoscopic surgery to facilitate visualization of intrathoracic structures.[1,2] One-lung ventilation has been safely and successfully used in dogs undergoing thoracoscopic lung lobectomy, mediastinal mass resection, and vascular ring anomaly procedures.[3–6] However, establishment and maintenance of OLV presents physiologic and logistical challenges.

Physiologically, OLV inevitably leads to some degree of pulmonary ventilation-perfusion mismatch and resultant hypoxemia. Acute lung injury (ALI)

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is an additional presumptive risk following OLV in dogs. Mechanisms for development of ALI are multifactorial and largely related to the higher ventilatory demands on the ventilated lung during OLV.[7] Acute lung injury is not uncommonly reported in humans following OLV; however, the emergence of lung-protective strategies has reduced the incidence to < 5%.[8,9] Acute lung injury has not been reported or investigated in dogs.[10]

Logistical challenges could include equipment availability, specialized training, and disruption to workflow. Devices currently available for OLV include endobronchial blockers or double-lumen tubes (DLTs). Endobronchial blockers utilize a balloon-tipped catheter to obstruct airflow to 1 main-stem bronchus. Although several types of endobronchial blockers in multiple sizes and lengths have been developed, Arndt endobronchial blockers (Cook Medical Inc) and EZ-Blockers (Teleflex Medical Inc) have been previously employed in clinical veterinary studies.[11–13] Double-lumen tubes have also been reported and involve a device formed from 2 tubes of separate lengths that are fused, enabling ventilation of one (OLV) or both sides for conventional two-lung ventilation (TLV).[12,14] Double-lumen tubes are designed for humans, and the anatomic differences between dogs and humans limit their utility to dogs weighing < 30 kg.[15,16] Alternatively, a standard single-lumen endotracheal tube can be used to selectively intubate a main-stem bronchus (selective intubation). Techniques reported for guiding placement of these devices include bronchoscopic, fluoroscopic, or blind placement.[12,14,16] Device selection usually depends on patient size, equipment availability, and the personal experience of the clinician establishing OLV.

The veterinary literature evaluating OLV is limited to experimental studies, case series, and case reports. Physiologic effects of OLV have been directly evaluated in the laboratory setting in purpose-bred healthy animals in both open and closed thoracic cavities.[17,18] In these studies, all dogs had decreased $Pa{O_2}$ due to ventilation-perfusion mismatch; despite this finding, all dogs had appropriate oxygen delivery to tissues.[17,18] However, in clinical case reports and case series, failure of OLV is cited as a cause of conversion.[19,20] Failure to establish and maintain OLV or conversion due to anesthetic complications such as significant hypoxemia may lead to conversion in certain cases. It is unclear whether the type of device, method of blockade, or sidedness of blockade play a role in complications associated with OLV.

The relationship between the risks of OLV and perioperative outcomes in dogs has not been directly evaluated in clinical cases. The purpose of this study was to better define the potential challenges and risks associated with OLV in clinical dogs. The primary aim of this study was to report on the placement and perioperative outcomes associated with OLV devices utilized in thoracoscopic surgery in clinical dogs. The secondary aim was to describe changes in $Pa{O_2}$ and $Pa{CO_2}$ for clinical cases in which OLV was induced.

Methods

Case selection

A retrospective evaluation was performed of medical records of dogs undergoing OLV for elective thoracoscopic surgery between January 1, 2013, and December 31, 2023, from 6 institutions (University of Pennsylvania Matthew J. Ryan Veterinary Hospital, University of California-Davis School of Veterinary Medicine, Colorado State University Veterinary Teaching Hospital, Ontario Veterinary College, Veterinary Specialty Hospital–North County, and Cornell University College of Veterinary Medicine). Inclusion criteria involved dogs undergoing thoracoscopic surgery with OLV techniques attempted, for which perioperative blood gas data were performed, and for which there was a 48-hour minimum follow-up period.

Data collection

Information collected from medical records included signalment, preoperative diagnostics (blood work and imaging reports), known comorbidities, surgical procedures performed, surgical time (first incision to last suture), anesthetic time (induction to extubation), anesthetic protocols, perioperative venous and arterial blood gas data, OLV technique and related information, intraoperative and postoperative complications, duration of hospitalization, 48-hour mortality, and date of death (if applicable). The method for establishing OLV was defined as the type of device used (if known), technique used for device placement (bronchoscopy, fluoroscopy, blind, or unknown), main-stem bronchus blocked (right, left, or alternating), and dog positioning (left lateral, right lateral, dorsal recumbency, or a combination thereof). The number of attempts and time to establish OLV were recorded. Successful establishment of OLV, total duration of OLV, and whether conversion was performed and why were documented. One-lung ventilation was considered successful when the intended lung was collapsed while appropriate ventilation of the other lung was maintained, allowing the planned procedure to be started. Conversion was defined as the transition from thoracoscopic surgery utilizing OLV to an open thoracotomy using conventional TLV because of either anesthetic or surgical complications.

Recorded surgical information included the type of procedure performed, whether additional procedures were performed, and the presence of intraoperative and postoperative complications. Recorded anesthetic information included the American Society of Anesthesiologists (ASA) Physical Status Scale,[21] drug and dosage for premedications, induction, maintenance (when available), and experience of the anesthesiologist or anesthesiology technician (when available). The anesthesiologist or anesthesiology technician's experience in managing OLV in years was ranked on a 4-point scale (0 to 3, with 0 = 0 to 3 years, 1 = 4 to 6 years, 2 = 7 to 10 years, and 3 = > 10 years). Anesthetic and surgical complications were recorded and graded on a scale from 1 (mild and without need for intervention) to 5 (leading to death or euthanasia) as described by the Veterinary Cooperative Oncology Group–Common Terminology

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Criteria for Adverse Events guidelines.[22] Hypoxemia and hypercapnia were reported if they were grade 2 or above, defined as Pa_{O_2} < 60 mm Hg or Pa_{CO_2} > 45 mm Hg that required intervention.

Venous and/or arterial preoperative, intraoperative, and postoperative blood gas data were collected and included oxygen partial pressure, carbon dioxide partial pressure, and base excess. Every dog included in this study had either arterial or venous blood gas data available. Arterial blood gas data were primarily utilized for analysis in this study. When available, blood gas data obtained under general anesthesia were delineated as data collected prior to initiation of OLV and data collected during OLV. Fraction of inspired oxygen (Fi_{O_2}) was assumed to be > 95% unless explicitly stated otherwise. Given the sizeable and variable nature of the data collected, arterial blood gas data were classified as data acquired prior to OLV initiation, during OLV, following discontinuation of OLV but before extubation, or after extubation. Data collected during OLV were further divided by time under OLV (0 to 30 minutes, 30 to 60 minutes, 60 to 120 minutes, and > 120 minutes).

Statistical analysis

All analyses were conducted in Stata (version 17; StataCorp LLC) with 2-sided tests of hypotheses and a *P* value < .05 as the criterion for statistical significance. Tests of normal distribution (Shapiro-Wilk test) were performed to determine the extent of skewness. For data with normal distribution, mean and SD were reported. Significantly skewed data were reported as median and range. Categorical variables (such as sex, signalment, and others) were evaluated with frequency counts and percentages. Univariable logistic regression was used to evaluate associations between potential confounders (age, weight, body condition score, and sex) and onset of complications including grade 2 or above hypoxemia, hypercapnia, conversion, and anesthetic or surgical complications. Variables with *P* < .20 on univariable analysis were included in a multivariable logistic regression model. Because of issues of complete separation (perfect prediction), univariable Firth logistic regression was then used to identify variables showing significant association with grade 2 or above hypoxemia or hypercapnia, conversion, anesthetic complications, or surgical complications. Variables evaluated included anticipated confounders (age, body condition score, weight, and sex) that were found to be significant on univariable analysis as well as OLV device type, method of placement, and sidedness of blockade. For each outcome of interest, the final multivariable regression model included only independent variables with *P* ≤ .05, and the ORs and associated 95% CIs were calculated for those variables.

Results

Ninety-three dogs met the inclusion criteria among the 6 participating institutions (University of Pennsylvania Matthew J. Ryan Veterinary Hospital [n = 3], University of California-Davis School of Veterinary Medicine [36], Colorado State University Veterinary Teaching Hospital [25], Ontario Veterinary College [12], Veterinary Specialty Hospital–North County [13], and Cornell University College of Veterinary Medicine [4]). There were 47 female dogs (40 neutered) and 46 male dogs (34 neutered). The median age was 9.5 years (range, 0.08 to 14.7 years) and median weight was 26.8 kg (range, 2.5 to 62.8 kg). The median body condition score was 5/9 (range, 1/9 to 9/9). Dogs included mixed-breed dogs (n = 25), Labrador Retrievers (16), Golden Retrievers (7), German Shepherd Dogs (5), Bernese Mountain Dogs (5), Beagles (3), Border Collies (3), American Cocker Spaniels (3), Australian Shepherds (2), Pembroke Welsh Corgis (2), Great Danes (2), Shetland Sheepdogs (2), Standard Poodles (2), and 1 dog from each of the following breeds: Australian Cattle Dog, Belgian Malinois, Borzoi, Cane Corso, Chow Chow, Coonhound (not further specified), Miniature Dachshund, Briard, Great Pyrenees, Mastiff, Miniature Schnauzer, Portuguese Water Dog, Rottweiler, Chinese Shar-Pei, and Weimaraner. One dog breed was not reported.

Thoracoscopic procedures included lung lobectomy (n = 64), thoracoscopic persistent right aortic arch correction (16), pericardiectomy (5), mediastinal mass removal (3), thoracic duct ligation (2), metastasectomy (2), pleural biopsies (1), pericardial window (1), and bullet removal (1). For dogs undergoing lung lobectomy, resected lung lobes included right caudal (n = 11), right middle (7), left caudal (7), left cranial (6), and right cranial (5). The lung lobe(s) resected were not reported for 38 cases. Seventeen dogs had > 1 procedure performed under the same anesthetic event. The ASA status was recorded for 90 dogs and was I for 1 dog, II for 31 dogs, III for 52 dogs, IV for 5 dogs, and V for 1 dog. The median total surgical time was 120 minutes (range, 30 to 335 minutes). After adjusting for dogs undergoing unrelated surgical procedures under the same anesthetic event, the median surgical time was 120 minutes (range, 30 to 309 minutes). The median anesthetic time was 292 minutes (range, 93 to 540 minutes). The anesthetist's experience in establishing OLV in years was reported in 44 cases (for either the attending anesthesiologist or anesthesia nurse). The anesthetist had 0 to 3 years of experience in 8 cases, 4 to 6 years in 4 cases, 7 to 10 years in 13 cases, and > 10 years in 19 cases.

One-lung ventilation was successfully established in 90 of 93 cases and established with the aid of bronchoscopy (n = 73) or fluoroscopy (14) in most cases. One-lung ventilation was established blindly in 4 cases, and the method of placement was not reported in 2 cases. Endobronchial blockers were most commonly used, with the EZ-Blocker being used in 39 dogs, Arndt endobronchial blocker in 29 dogs, and an unspecified endobronchial blocker in 3 dogs. One-lung ventilation was established with a double-lumen endobronchial tube (Robertshaw; sidedness not specified) in 15 dogs. Selective bronchial intubation with a single-lumen endotracheal tube was used in 1 dog. The type of device used to establish OLV was not specified for 6 dogs. Forty-seven dogs underwent

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left-sided blockade, 40 dogs underwent right-sided blockade, and 6 dogs underwent alternating unilateral blockade. For initial OLV device placement, the dog was positioned in right lateral recumbency for 38 cases, left lateral recumbency for 30 cases, dorsal recumbency for 21 cases, and sternal recumbency in 2 cases. Dog positioning was not reported for 2 cases. In 80 cases, dogs remained in the same position between device placement and surgery. In 11 cases, dogs were repositioned between device placement and surgery for alternating blockade.

Of the 90 cases in which OLV was initially successfully established, 23 cases were ultimately converted to an open approach. Four cases were converted because of anesthetic complications involving hypercapnia alone (n = 2 cases) or hypoxemia and hypercapnia (2 cases). Ten cases were converted because of surgical complications including excessive tumor size, excessive adhesions, hemorrhage, and poor visualization. Nine cases were converted for undisclosed reasons.

Unless explicitly stated otherwise, Fio_2 was assumed to be > 95%; Fio_2 was reported in 64 cases, and the median was > 95% (range, 40% to > 95%). Arterial blood gas data were reported for 84 cases. Median arterial oxygen tension over time and median arterial carbon dioxide tension over time are summarized in **Tables 1 and 2**. Data were pooled over specific time points as previously described (prior to initiation of OLV, 0 to 30 minutes under OLV, 30 to 60 minutes under OLV, 60 to 120 minutes under OLV, > 120 minutes under OLV, after OLV was discontinued, and following extubation). The number of arterial blood gas measurements per time point, median, and range of arterial oxygen tension and arterial carbon dioxide tension for each time point were recorded. Ultimately, over the duration of OLV, median Pao_2 was decreased. Following discontinuation of OLV, Pao_2 improved. Following extubation and on room air, Pao_2 decreased appropriately. Assessment of median arterial carbon dioxide tension over time demonstrated that dogs were persistently hypercapnic over the duration of OLV and that it generally resolved following extubation.

Intraoperative hypercapnia was reported in 73 of 93 cases. Grade 2 hypercapnia was reported for 62 cases and grade 3 hypercapnia for 11 cases. Interventions performed for grade 3 hypercapnia included instituting positive end-expiratory pressure (n = 4), increasing tidal volume and respiratory rate (2), and converting to TLV (4). No intervention was recorded in the anesthetic record for 1 case with grade 3 hypercapnia; hypercapnia was sustained throughout the procedure, with documented resolution postoperatively. Intraoperative hypoxemia was reported in 16 cases. Grade 2 hypoxemia was reported for 10 cases and grade 3 hypoxemia for 6 cases. Interventions performed for grade 3 hypoxemia included adjustment of ventilation settings (n = 2) or removing a lung blockade (4).

Postoperative complications were reported in 34 of 93 cases. Of these postoperative complications, 22 of 34 were grade 1, 6 of 34 were grade 2, and 6 of 34 were grade 3. No grade 4 or 5 postoperative complications were reported. Grade 2 complications included hypoxemia requiring oxygen supplementation (n = 1), hypotension requiring colloidal support (1), allergic drug reaction (1), hypothermia requiring heat supplementation (1), incisional dehiscence from an oral procedure performed at the same time

Table 1—Perioperative outcomes and complications, including arterial blood gas alterations, were evaluated in 93 dogs undergoing thoracoscopic surgery in which one-lung ventilation (OLV) was utilized from January 2013 to December 2023. The Pao_2 values in millimeter of mercury at specific time points in dogs undergoing OLV for thoracoscopic surgery are based on pooled data from surveyed animals.

	Median Pao_2 (mm Hg)	Range (mm Hg)	No. of blood gas samples
Before OLV	358	81–550	62
0–30 min OLV	170	54–621	38
30–60 min OLV	215	93–564	11
60–120 min OLV	218	48–404	17
> 120 min OLV	185	80–444	16
After OLV	385	314–455	2
After extubation	82	56–601	102

The number of blood gas samples at allotted time points is demonstrated as N in the last column.

Table 2—The same cohort as in Table 1 is presented here. The $Paco_2$ values in millimeter of mercury at specific time points in dogs undergoing OLV for thoracoscopic surgery are based on pooled data from surveyed animals.

	Median $Paco_2$ (mm Hg)	Range (mm Hg)	No. of blood gas samples
Before OLV	45	21–76	62
0–30 min OLV	54	31–88	38
30–60 min OLV	50	32–66	11
60–120 min OLV	54	39–73	17
> 120 min OLV	57	32–122	16
After OLV	50	37–62	2
After extubation	38	24–66	102

The number of blood gas samples at allotted time points is demonstrated as N in the last column.

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as the primary thoracoscopic procedure (1), and paraparesis (1). Grade 3 complications included bronchopleural leak following lung lobectomy requiring blood-patch pleurodesis (n = 1), postoperative pneumothorax requiring a chest drainage system or intermittent aspirations (2), pneumonia (1), recurrent esophageal tear requiring revision surgery following persistent right aortic arch correction (1), or unknown (1). The median duration of hospitalization was 2 days (range, 0.5 to 7 days). After 48 hours postoperatively, 93 of 93 dogs were alive.

After adjusting for confounding variables, it was found that dogs with left bronchus blockade had significantly lower odds of grade 2 hypoxemia versus dogs with right bronchus blockade (OR, 0.18; 95% CI, 0.04 to 0.83; $P = .028$). Dogs with alternating blockade had significantly higher odds of grade 2 hypoxemia versus dogs with right bronchus blockade (OR, 18.58; 95% CI, 1.36 to 253.63; $P = .028$).

Discussion

In this cohort, nearly all dogs undergoing thoracoscopic surgery in which OLV was attempted had successful initiation of OLV. Additionally, most cases received endobronchial blockers (EZ-Blockers, Arndt endobronchial blocker, or an unspecified endobronchial blocker) placed with the use of bronchoscopic guidance. However, there were a variety of devices and techniques utilized to establish OLV, which speaks to the fact that there is room for refining the optimal technique for establishing OLV in veterinary patients. It may also be inferred that the technique utilized to establish OLV is largely guided by the clinicians' previous experience and equipment available. Although there was a moderate rate of hypoxemia and hypercapnia, the rate of conversion from OLV to TLV secondary to either was low. Additionally, median duration of hospitalization was short and short-term outcomes were excellent, with no dog dying of complications related to OLV within the first 48 hours after surgery.

It is well established that some degree of hypoxemia will be experienced with OLV because of the induction of ventilation-perfusion mismatch. The effect of OLV on cardiopulmonary function has specifically been evaluated in the laboratory setting in both open and closed thoracic cavities.[17,18] In both the open and closed thoracic cavities, $Pa{O_2}$ was significantly decreased and $Pa{CO_2}$ was significantly increased under OLV when compared to TLV.[17,18] In 1 report,[17] the $Pa{O_2}$ was reduced to a mean of 170 mm Hg under OLV from a mean of 448 mm Hg under TLV and $Pa{CO_2}$ increased to a mean of 44 mm Hg under OLV from a mean of 40 mm Hg for TLV in the closed thoracic cavity. While significant, these changes did not affect oxygen delivery in healthy laboratory dogs in either of the aforementioned studies.[17,18] This finding is comparable to the arterial blood gas trends identified in the present study, which identified reduced median $Pa{O_2}$ and increased median $Pa{CO_2}$ following induction of OLV from TLV. The measurement of oxygen delivery was beyond the scope of this retrospective study; yet, despite the changes observed in $Pa{O_2}$ and $Pa{CO_2}$, most dogs experienced good clinical outcomes. Despite the challenges faced with OLV, these results demonstrate OLV to be an acceptable and successful technique that can be utilized in thoracoscopic procedures.

Side of blockade and alternating unilateral blockade both appeared to alter a dog's susceptibility to hypoxemia. Dogs with right-sided blockade had higher odds of developing grade 2 and above hypoxemia when compared to dogs with left-sided blockade. Dogs with alternating unilateral blockade had higher odds of developing grade 2 and above hypoxemia when compared to dogs with right-sided blockade alone. There may have been 2 causes to account for these findings: procedural challenge and differential hypoxemia between right and left lungs. At the bifurcation of the trachea and upon entering the right principal bronchus, the lobar bronchus to the right cranial lung lobe branches off laterally immediately,[23] which is in contrast to the left cranial lung lobe, which branches off the left principal bronchus more distally.[3] Clinically, the authors have experienced a greater challenge in establishing right-sided blockade, suspected to be due to the aforementioned anatomic differences. Procedural challenge is difficult to document retrospectively, and the overwhelming success of obtaining OLV compared to attempts in this population made correlating sidedness of blockade with success or failure of OLV impossible. Additionally, the duration of time it took to achieve OLV was not reported. However, it is possible that challenges in obtaining OLV in right-sided blockade leading to intermittent loss of right-sided blockade or intermittent, unintended bilateral blockade, malpositioning of devices, and altered oxygen delivery could have been related to the higher odds of developing grade 2 or above hypoxemia observed in this cohort. Secondly, in both humans and dogs, the right lung has greater volume compared to the left, which has direct impacts to ventilation-perfusion matching. In humans in a supine position, 55% of total cardiac output is delivered to the right lung and 45% is delivered to the left lung.[24] When positioning is changed to lateral recumbency, the dependent lung receives 10% more cardiac ouput.[24] In dogs, 58% of the total cardiac output is delivered to the right lung and 42% is delivered to the left lung.[25] It has been demonstrated in humans that right-sided surgery (with the left side receiving OLV) is a risk factor for the development of hypoxemia.[24,26,27] Seemingly, the increased risk for hypoxemia is directly related to the differential perfusion between the left and right lungs. The right lung receives a higher percentage of perfusion and thus contributes to oxygenation more than the left lung. Consequently, right-lung collapse during right-sided surgery with left OLV increases the risk for greater oxygen desaturation. The results of the current study suggest a similar phenomenon in dogs.

In humans undergoing OLV, there is ongoing attention paid to techniques aimed at reducing *postoperative pulmonary complications* (PPCs), an umbrella term capturing primary respiratory complications such as ALI that occur postoperatively. In people undergoing OLV, incidence of PPCs is at

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least comparable to TLV,[28,29] with some studies identifying greater risk in patients undergoing OLV.[30,31] Techniques such as positive end-expiratory pressure, reduction in tidal volumes, tolerance of mild blood gas derangements, and altered Fio_2 have been investigated in an effort to minimize PPCs in people.[7,8] While the short-term outcomes in this population of dogs were overall good, a small portion of dogs suffered complications such as prolonged hypoxemia requiring oxygen supplementation and aspiration pneumonia, which could fall under the category of PPCs. Future studies prospectively evaluating some of these techniques relative to short-term outcomes in dogs undergoing OLV or TLV are indicated to better understand the role of anesthetic parameters in the onset of PPCs.

In this cohort, endobronchial blockers were most commonly used and placed via bronchoscopic guidance to establish OLV. The EZ-Blocker catheter (Teleflex Medical Inc) has a balloon on each side of a forked end, which allows the flexibility to block one side over the other.[11] The Arndt endobronchial blocker (Cook Medical Inc) was also used with high frequency in this cohort. This device has a balloon-tipped catheter with a snare located at the end of the blocker, which can be advantageous when a bronchoscope is used, as it can more easily be attached and guided under direct visualization.[13] The clinical performance as it specifically relates to the device type used for OLV is rarely reported. Double-lumen tubes were used infrequently in this cohort. Clinical use of DLTs is uncommonly reported, and, as these tubes are designed for human use, appropriate use in the dog may be difficult depending on the size of the dog and side of blockade. One case series[16] reported difficulty in blind placement of DLTs in 4 of 7 cases. Another case report[15] identified prolonged intraoperative hypoxemia secondary to incorrect placement of a DLT resulting in inadvertent occlusion of the right cranial lung lobe. In the cohorts described in these studies, small sample sizes, infrequent use of DLTs, and infrequent performance of blind or fluoroscopic placement precluded the ability to investigate for associations between the technique used and outcomes, such as hypoxemia. Further investigation is warranted to identify the ideal technique for establishing OLV in dogs.

Limitations of this study were largely related to its retrospective nature. Reported data were inconsistent across institutions, limiting the ability to further assess certain factors such as the time taken to establish OLV and trends in blood gas data. Additionally, while hypoxemia and hypercapnia were commonly reported, it did not always result in conversion. For each case, the degree of hypoxemia that determined the need for conversion was not defined. Fio_2 was not reported for every case and some institutions altered Fio_2 during the anesthetic event, which will alter partial pressures of oxygen in the blood. Furthermore, results may have been affected by differences in altitude at participating institutions, which could have altered inspired oxygen pressures. The inclusion criteria for this study were purposefully broad, but resulted in having a cohort with no standardized surgical procedure or anesthetic protocol, which may have introduced confounding variables to our analyses.

In this cohort, OLV was successful in the majority of cases. Multiple methods and device types may be used to establish OLV successfully, and clinician preference appears to be a reasonable determining factor. Complications that could be related to OLV, such as intraoperative hypercapnia and hypoxemia, were commonly observed and predominantly grade 2 in severity. This study was the first to demonstrate an apparent relationship between the side of the blockade and severity of hypoxemia in dogs, though further investigation with prospective data collection is necessary to enhance understanding of this difference. Most reports of hypercapnia and hypoxemia did not result in conversion and typically resolved postoperatively. Ultimately, OLV appears to be well tolerated in clinical dogs undergoing thoracoscopic surgery.

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