

ALVEOLAR LUNG RECRUITMENT MANEUVER UTILIZATION AMONG
TRANSPLANT CLINICIANS IN ARIZONA

by

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GRADUATE COLLEGE

As members of the DNP Project Committee, we certify that we have read the DNP project prepared by *Benjamin S. Bergstrom*, titled *Alveolar Lung Recruitment Maneuver Utilization Among Transplant Clinicians in Arizona* and recommend that it be accepted as fulfilling the DNP project requirement for the Degree of Doctor of Nursing Practice.



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Final approval and acceptance of this DNP project is contingent upon the candidate's submission of the final copies of the DNP project to the Graduate College. ®

I hereby certify that I have read this DNP project prepared under my direction and recommend that it be accepted as fulfilling the DNP project requirement.



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DEDICATION

This DNP project is dedicated to my best friend and wife, Tori. Your unwavering support throughout this work has given me the courage to continue to do what I love while loving what I do.

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ABSTRACT

The reservation of lung transplant procedures as a final treatment measure for patients with acquired end-stage pulmonary disease is partly due to the lack of supply, which mostly comes from brain dead donors. Separate from the other life-saving transplantable organs that have progressively increased in transplant rates over the last decade, the national ratio of lung transplantation has remained stagnant (Bergstrom, 2018). Transplant clinicians medically manage authorized brain dead organ donors in Arizona (AZ) according to their clinical judgment that is supplemented by the Organ Procurement Organizations (OPO) Clinical Practice Guidelines (CPG). The goal is to maximize the gift of donation by increasing the number of organs transplanted per donor (OTPD). The United Network for Organ Sharing (UNOS) sets the benchmark for the Expected (E) OTPD, and in AZ the Observed (O) OTPD ratio (i.e., O: E) has been below that benchmark. Meeting the organ-specific diagnostic endpoints of the Donor Management Goals (DMG) demonstrate organ system recovery and suitability for transplant.

Alveolar recruitment maneuvers were at the forefront of the pulmonary management regimes of potential lung donors, and there were three in the CPGs at Donor Network of Arizona (DNAZ), the federally designated OPO of AZ. Each of the three methods have been tested at DNAZ in the past years and each has shown some ability to improve lung transplant rates but, clear superiority of one method has not been definitively established. Despite the prior utilization of these measures, according to an analysis of CPGs utilized and DMGs met, the use of the techniques has waned in the last year. Underutilization of alveolar recruitment maneuvers was the suspected reasoning behind the O: E gap. This project used theoretical foundations that aimed to improve utilization of the DNAZ CPGs by; (1) exploring the reasoning behind why

they are avoided, (2) creating and presenting a learning lesson based on that assessment (3) evaluating the learning lesson and (4) closing the O: E gap by improving transplant metrics.

INTRODUCTION

Midyear of 2018, the Organ Procurement Transplant Network (OPTN)/United Network for Organ Sharing (UNOS) reported nearly 115,000 patients awaiting organ transplants and of that number over 1,400 patients were requiring lungs (OPTN/UNOS, 2018). There is potential for eight transplantable organs from a brain dead donor two of which are paired lungs. While the number of operations for the other six organs have increased over the past five years, the national average of lungs transplanted per donor (LTPD) has remained approximately 21%, and in Arizona (AZ), highly variable (Bergstrom, 2018) (Figure 1). Donor Management Goals (DMGs) are endpoints set forth by DNAZ that transplant clinicians attempt to reach before offering organs to transplant centers to demonstrate organ transplantation suitability (Appendix A). Meeting seven out of the nine DMGs have shown increased organs transplanted per donor (OTPD) and improved graft function in recipients (Malinoski, Patel, Daly, Oley, & Salim, 2012). However, the lung function DMG is rarely achieved and thus the overarching intention of this project is to identify a way to increase the DMGs and therefore make more organs available for transplant in brain dead organ donors.

Background

The Uniform Anatomic Gift Act of 1968 granted adults over 18-years old the power to donate their organs and tissues for the use of transplant and research. It was accepted by all 50 states by 1972 and resulted in the National Organ Transplant Act of 1984. As a result, the private, nonprofit organization, UNOS was awarded the contract to operate OPTN in 1986 by the Health Care Financing Administration. Along with the United States Health Resources and Services Administration, UNOS designated 58 organ procurement organizations (OPOs) based

on diagnostic service areas; Donor Network of Arizona (DNAZ) was the OPO for the state of Arizona (UNOS, 2018). The OPO was responsible for procuring, preserving, and allocating organs for transplant under UNOS guidelines (Youn & Greer, 2014).

Brain Death

Although the number of circulatory death donors was increasing in proportion to donation after brain death, the vast majority of lung transplantation occurred between brain dead donors and living recipients (UNOS, 2018). Lung donation can only happen after death, and the American Academy of Neurology defines death as, “An individual who has sustained either irreversible cessation of circulatory and respiratory functions, or irreversible cessation of all functions of the entire brain, including the brainstem, is dead” (Wijdicks, Varelas, Gronseth, & Greer, 2010, p. 1119).

Brain death resulted when the intracranial pressure rose to a critical point beyond that of circulation and the brain-stem herniated through the foramen magnum causing cerebral and cerebellar death (Courtwright & Cantu, 2017). Often in this course, a phenomenon recognized as *Cushing's Triad* ensued and was characterized by: (1) increased pulse pressure, (2) reflex bradycardia, and (3) irregular respirations, which were the result of substantial catecholamine release (Rech, Moraes, Daisy, Czepielewski, & Leitao, 2013). This sympathetic nervous system storm was thought to be a proliferative mechanism as the body attempts to maintain cerebral perfusion. This phenomenon often leads to cardiac stunning and subsequent cardiopulmonary complications such as ventilation to perfusion mismatch and neurogenic pulmonary edema (Kirschbaum, 2010). When the cardiovascular and pulmonary systems fail to meet the metabolic demands of the brain after herniation completed, hypotension often occurred because of the

abolishment of the hypothalamic-pituitary axis. The combination of spinal, cardiogenic, and distributive shock has significant consequences which have led to the cardiovascular collapse in upwards of 30% of those patients who experienced the brain death process (Bergstrom et al. 2017). This hypertensive crisis, followed by a post-herniation hypotension phenomenon negatively affects all transplantable organs and the typical pathophysiologic consequences categorized by systems includes: *cardiovascular* - hypotension and arrhythmias; *pulmonary* - atelectasis and shunting; *endocrine* - diabetes insipidus and hypothyroidism; *thermoregulation* – poikilothermia and neurogenic hyperthermia; *renal* - tubular necrosis and acute kidney injury; *hematologic* - disseminated intravascular coagulation and inflammatory dysfunction such as systemic inflammatory response syndrome (Youn & Greer, 2014). In the perioperative donor management phase, aims are to mitigate these responses and to improve or maintain organ systems function by preserving the beating-heart and mechanically ventilated lungs while organ recipients are contacted to receive their gift.

Local Problem

In 1999, UNOS created the *Critical Pathway for the Organ Donor* that recommended physiologic goals as an approach to donor management which included specific treatments and monitoring (UNOS, 2018). This document hasn't been updated since 2006 and primarily based on opinion grade evidence (Youn & Greer, 2014). Therefore, in 2019 at the time of this article's publication, it was mainly at the discretion of the transplant clinician to determine how goals were achieved and by what donor management methods. It has long been recognized that national lung transplant rates were not only low but highly variable between OPOs. Therefore, DNAZ, along with their local lung transplant center, Saint Joseph's Hospital and Medical Center

(Phoenix, AZ) conducted an investigational review of the internal practices and those in the literature to explore relationships between recruitment strategies that could potentially increase LTPD in 2013. Evaluation of the available data indicated that the choice of pulmonary management of the brain dead donor was inconsistent (Bergstrom, 2018). Research was lacking to support either of the methods of superiority, therefore DNAZ initiated a performance improvement initiative using a plan-do-study-act (PDSA) cycle (Institute for Healthcare Improvement, 2016) to inform which process, if any, would increase lung transplant rates by randomizing the two recruitment maneuvers in the DNAZ CPGs (Bergstrom, 2018) (Appendices B & C). The conclusions of the trial were not clear, which fueled an additional PDSA with a similar sample of donors to those in the first trial. The second-stage PDSA design was a prospective sample comparing inverse ratio ventilation (IRV) (Appendix D) to the other two maneuvers that were compared in the first PDSA. Overall, the IRV method demonstrated increased lung transplant rates when compared to the national average and between the other two methods. Following the completion of the second PDSA trial the 2015 update of DNAZ CPGs contained all three lung recruitment maneuvers tested. Despite improvements in lung transplant rates leading to an evidence-based CPG update, one year later there were 440 patients authorized to donate lungs in AZ of which only 22% did. Therefore, the local problems involved a low ratio between DMGs met versus missed and the number of OTPD which was less than the expected benchmark set forth by the UNOS.

Brain Dead Donors and Transplant Rates in Arizona

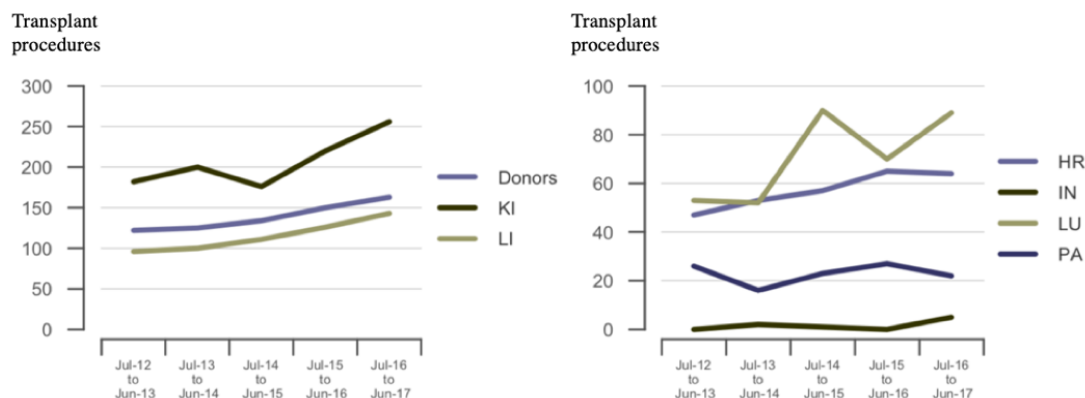


FIGURE 1. Brain dead donors and organs transplanted in Arizona. (Recreated from the Scientific Registry of Transplant Recipients. Figure C2. Brain Dead Donors and Organs Transplanted in Arizona. Accessed October 3, 2018 from <https://www.srtr.org>. KI = Kidney; LI = Liver; HR = Heart; IN = Intestine; LU Lung; PA = Pancreas)

Purpose

The purpose of this project was to study the reasons that transplant clinicians did not use the CPGs and to improve the knowledge, attitudes, and utilization of the guidelines used to manage the lungs of the donor patient. A needs assessment questionnaire was used to evaluate the barriers that transplant clinicians had in place that prevented them from choosing to use the CPGs. The assessment of experiences and presumptions of transplant clinicians in applying the DNAZ recruitment measures provided insight into an educational in-service that highlighted the actions that could be taken to overcome the obstacles to recruitment and thereby improve DMGs met and OTPD.

Study Question

Are transplant clinicians (P) who receive an evidence-based practice (EBP) in-service on the benefits of mechanical lung recruitment strategies aimed at improving DMGs (I), compared to their practice before the EBP in-service (C), more likely to attempt to employ the DNAZ

CPGs that positively impact the number of organs available for transplant (O) over a two-month period (T)?

Theoretical Framework

Evidence-based practice models aim to implement evidence into practice, and tools like CPGs should apply theoretical frameworks that improve staff adherence to their methods (Buckwalter et al., 2017). Many other theoretical models precluded application to the proposed population because of the unique nature of the organ donation process and the OPO of Arizona. Because of the previously mentioned reasons, and because donor management occurs in the care-setting in which the theory originated (i.e., critical care), the Iowa Model best informed the inquiry of this scholarship.

Variables

The Iowa Model found application to incorporate successful implementation strategies into practice. Importantly, its underpinnings contained criteria that paralleled the organization in which it was applied (Rycroft-Malone & Bucknall, 2010). For example, success in like projects assumed three necessary components of the organization that included: (1) an intact interdisciplinary team that worked effectively together; (2) which performed literature reviews, evaluations, and synthesis of supporting information highlighting the need for change; and (3) the process was one that was structured and systematic (Doody & Doody, 2011). These characteristics were native to the transplant clinician and culture of DNAZ with their exposure to PDSA cycles (Institute for Healthcare Improvement, 2016) described previously with their lung recruitment strategies.

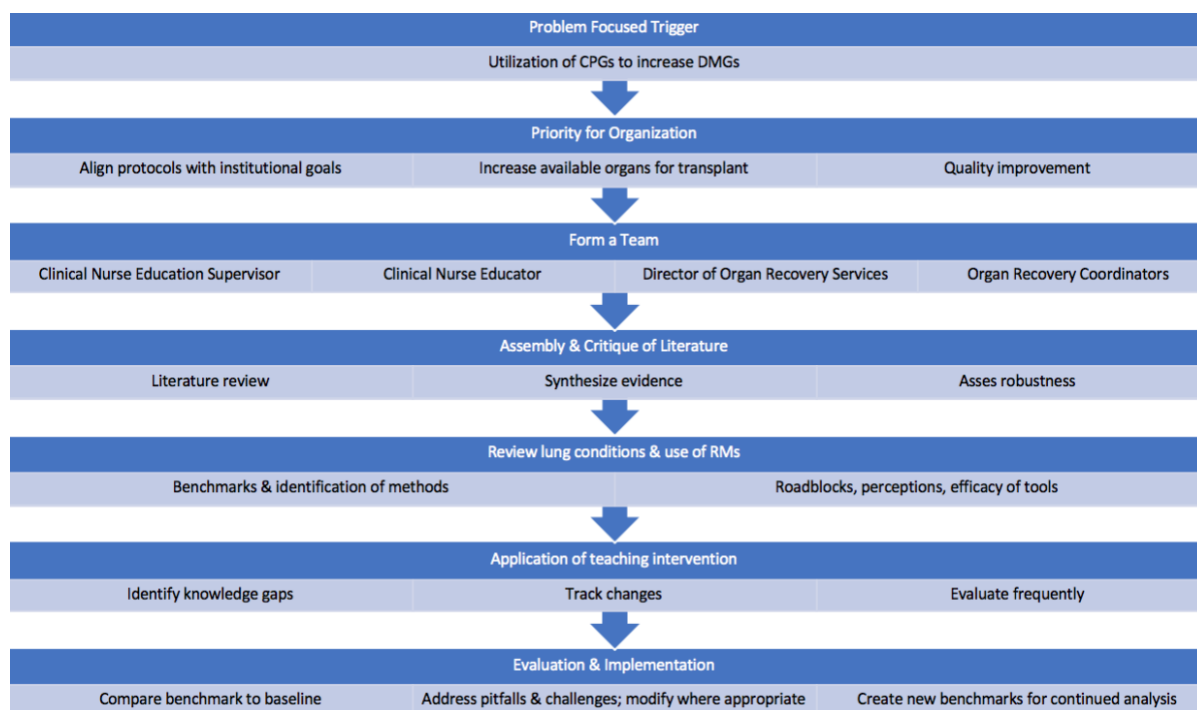


FIGURE 2. The Iowa model of evidence-based practice. (Implementation of a protocol for use of recruitment maneuver guidelines on potential lung donors. Used/reprinted with permission from the University of Iowa Hospitals and Clinics, copyright 2015. Iowa Model Collaborative. (2017). Iowa model of evidence-based practice: revisions and validation. *Worldviews on Evidence-Based Nursing*, 14(3), 175-182.)

The prevalence of decreased DMGs met in conjunction with the lack of alignment between transplant clinicians who abide by the CPGs created the situation of a problem-focused trigger (Figure 2). Furthermore, there was a performance gap of the OTPD benchmark set by UNOS, which warranted prioritization within the organization. Because DNAZ had already developed proper screening methods and implementation tools (See *Possible Rule Outs* - Appendices B, C & D) there was support for the need to review the interventions and to understand the barriers, physiology, and limitations of each recruitment strategy to prevent harm to the donor. Assessing the transplant clinician's perspectives of the supported topic identified noteworthy details of knowledge gaps and practice barriers they experienced while implementing the protocols in the DNAZ CPGs (Table 2). After applying the needs assessment results to the

teaching intervention, the project was evaluated by the participants and by a comparison between the O: E benchmark and the ratio of DMGs met.

Concept Analysis

Donor Management Goals

In 2008, the DMG spreadsheet was created and data were gathered prospectively among eight OPOs (including DNAZ) that measured each organ donor's cardiovascular, pulmonary, renal, and endocrine status (Malinoski, Patel, Daly, Oley, & Salim, 2012) (Appendix A). The data suggested that meeting at least seven out of the nine critical care endpoints of DMGs was associated with improved organ utilization (i.e., OTPD & graft function) (Franklin, Santos, Smith, Galbraith, Harbrecht, & Garrison, 2010; Malinoski et al., 2012). Based on this premise DNAZ used the DMG tool to promote a goal of meeting performance merits by annually appraising if transplant clinicians met these landmarks. Standards for clinical-ladder growth within the organization were also primarily based on consistently meeting seven DMGs. For example, one of the criteria for being a fourth-level transplant clinician involves meeting DMGs at least 80% of the time while managing the donor.

Observed Versus Expected Ratio

In 2012 the UNOS developed a dynamic grading tool that measured gaps in OTPD by comparing donor characteristics and local and national trends. To quantify organ utilization ratios Observed (O), or actual transplant rates, are compared to the Expected (E) OTPD rates by the gap analysis indicator (UNOS, 2018) (Table 4). An O: E value of zero indicated that the OPO was at the benchmark for meeting OTPD; a positive value reported a higher than expected performance, and; a negative value was subpar. *Standard Criteria Donors* were donors under the

age of 65; or 55 – 65 years with less than two of the following three conditions: (1) a history of hypertension, (2) a plasma creatinine over 1.3 mg/dL and (3) a stroke or ruptured aneurysm as the cause of death. *Extended Criteria Donors* were all donors over the age of 65; or 55-65 years with two or more of the following; hypertension, creatinine over 1.3 mg/dL; or stroke as the cause of death. Based on this tool, the expected number of organs transplanted per Standard Criteria Donor was 4.3, and Extended Criteria Donors was 2.5.

Lung Recruitment

Of the nine DMGs, a commonly missed goal at DNAZ was the *partial pressure of arterial oxygen (PaO₂) to the fraction of inspired oxygen (FiO₂) P: F ratio* (Appendix A). To address this concern, in 2011, pulmonary recruitment Maneuvers were introduced into the Donor Network of Arizona Clinical Practice Guidelines (DNAZ CPGs) as a reflection of changing trends in using ventilator techniques for lung donor management. The 2015 revision contained three mechanical ventilation techniques (Appendices B, C & D) known as *alveolar recruitment maneuvers*, which aimed to increase the available lungs for transplant by meeting the metrics of the DMGs. In the brain dead donor with a P: F less than 350 any of the three recruitment maneuvers in the DNAZ CPGs were applied at the discretion of transplant clinician. The physiologic objective of lung recruitment involved applying a mechanical ventilation technique that balanced minimal barotrauma while applying adequate ventilating pressure to reverse atelectasis. Recruitment maneuvers can be classified as *non-continuous recruitment maneuvers* (NCRMs), or *continuous recruitment maneuvers* (CRMs) and nationally, methods of each vary between OPOs (Papadokos, Lachmann, & Koch, 2010). Most research supported using some form of lung recruitment to increase organ utilization, specifically lung transplant rates

(Table 1). Lungs transplanted per donor (LTPD) was the endpoint of much the research when reporting efficacy and was an outcome consideration of this project. Over the past decade, national trends have shifted from NCRMs to CRMs as they were thought to reduce ventilator-associated lung injuries that were common to the high peak inspiratory pressures (PIPs) experienced in periodic modes of recruitment (Dikdan, Mora-Esteves, & Koneru, 2012). The application of each alveolar recruitment maneuver involved setting ventilator parameters with the aim to improve ventilation to perfusion matching from atelectatic etiologies.

Continuous Recruitment Maneuvers

In a descriptive analysis of CRMs, Powner and Graham (2010) were among the first authors to explain the physiology of CRMs and how they mitigated atelectasis in organ donors by utilizing lower PIPs and higher MAPs using a mode of ventilation similar to IRV (Appendix D). In living patients with acute lung injuries, protection from the pressure gradient required to deliver the set amount of gas to attain normocapnia and oxygenation was maintained by applying a mode of ventilation that led to a National Guideline Clearinghouse described by Cho et al. (2016) in the ARDSnet Protocol. This method involved reducing tidal volumes to 6-8 mL/Kg ideal body weight and setting a higher PEEP (i.e., from 8-10 cm H₂O). This *Lung Protective* strategy was thought to promote and sustain inflation of collapsed alveoli in living patients with acute respiratory diseases by increasing wall tension during the expiratory phase (i.e., PEEP) and decreasing it during the inspiratory phase. Another mechanism of continuous ventilation involved maintaining wall tension during the inspiratory phase by reversing the inspiratory to expiratory time (i.e., Airway Pressure Release Ventilation). This method has been used in organ

donors successfully as observed in a retrospective single-center control trial by Hanna, Seder, Weinberger, Hagan, and Janczyk in 2011.

Mascia and colleagues (2010) applied a CRM to organ donors that was adopted from the high-PEEP-low-tidal volume method described by the aforementioned National Guideline Clearinghouse ARDSnet protocol. It was randomly applied to 59 consecutive donors in 12-different critical care units over five years. The LTPD doubled when compared to the control group, which were managed according to traditional protocols (control 27% vs. 54% treatment, $p < .05$). Although these results seemed promising, this trial had several flaws: (1) it failed to define traditional methods of management, (2) and it was terminated early due to lack of funding. Therefore, the sample size was not large enough to achieve adequate statistical power which would limit the study's external validity and subsequent adoption into practice (Polit & Beck, 2017).

Non-Continuous Recruitment Maneuvers

Compared to CRMs, the theoretical fundamentals of NCRMs involved applying *brief* periods of airway pressures that were high enough to overcome the opening pressure of collapsed alveoli. Variations of achieving these goals typically either involved using continuous positive airway pressure (CPAP) (sigh breaths) or escalating PEEP to a maximal PIP (Courtwright & Cantu, 2017). Modifications of lung management regimes using different CPAP pressures and methods date back to a large clinical trial performed in Quebec, Canada, where a protocol was applied to a continuous sample of donors over three years ($n=430$) (Noiseux et al., 2009). The authors found improved transplantation rates from an average of 20% LTPD before initiating the

intervention, to 33% the following year. Unfortunately, the gains were not sustainable as the percent of LTPD decreased to 24% in years two and three following the intervention.

In a similar trial performed by Kirschbaum (2010), a higher pressure of CPAP (40 cm H₂O vs. 30 cm H₂O by Noiseux et al., 2009) was initiated on a continuous sample of donors in Michigan for 30-seconds every 20-minutes for a total of three cycles. This data demonstrated an overall improvement of 10% of transplantable lungs per donor and the raw increase of 265% lungs transplanted per year. However, like the trial performed by Noiseux et al. (2009), there were many flaws including lack of randomization, lack of an actual control group, and although national transplantation rates are similar between countries (Canada [20%] vs. the US [21%]), representativeness of the donor population is a threat to external validity (Polit & Beck, 2017).

In contrast to the gains reported by Kirschbaum and Noiseux by using the CPAP methods of recruitment in organ donors, Fan and colleagues found a negative impact of these methods when applied to live patients with ARDS (2012). In their secondary analysis of a large, 30-hospital randomized control trial (RCT) in patients with ARDS that had a CPAP of 40 cm H₂O protocol performed, these authors used the Acute Physiology, and Chronic Health Evaluation (APACHE II) score to grade the risk versus benefit of the intervention. By using this well-validated tool, they found a positive correlation between the number of CPAP cycles performed and the risk of respiratory desaturation and cardiovascular complications. Although Fan's analysis on living patients is not directly generalizable to the donor population, the CPAP of 30 cm H₂O protocol also received the ranking of the least safe mode of lung recruitment methods in the DNAZ CPGs according to the needs assessment form (Table 2). Therefore, it would be prudent to assume that complications can arise from alveolar recruitment especially because, in

their trial, they did so with an incident occurrence of 22% of the patients receiving the intervention (Fan et al., 2012). The authors concluded by questioning the efficacy of applying such large amounts of pressure to patients with ARDS.

Synthesis of Evidence

The purpose statement that offered knowledge of this inquiry was to inform the following PICOT question: in brain dead organ donors who have received recruitment maneuvers (P) is there evidence to support which method (I) is superior in improving lung function (C) as demonstrated by improved lung transplantation rates (O) in the perioperative period (T)? The synthesis of evidence examined three categories related to lung transplant literature: 1) primary sources that utilized NCRMs, 2) those that used CRMs, 3) and secondary sources including meta-analyses that informed mechanical lung management.

Searches performed were in the Cochrane Library, PubMed and CINAHL databases using the phrases “lung donor management,” “organ donor management,” “lung donor transplant,” “lung recruitment,” and “maneuver.” Search results were filtered to obtain background literature as well as the primary research articles described in Table 1. Excluded items included those informing novelty transplant center mechanics (e.g., ex-vivo lung conditioning) because they were not directly related to mechanical techniques of cadaveric lung donor management.

TABLE 1. *Synthesis of evidence.*

Author/Article	Qual: Concepts or Phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
<p>Bergstrom, B. (2018, January). A randomized control trial of lung recruitment maneuvers in brain dead donors: Continuous positive airway pressure versus incremental positive end expiratory pressure increase. Poster session presented at the Eighteenth Annual State of the Art Winter Symposium, Miami, FL. American Journal of Transplantation, 18(S2), 29-30</p>	<p>Intervention (I): Baseline ABG, decrease Vt to 7 mL/kg IBW and PEEP to 10 cm H₂O for 15 min and increase to 20 cm H₂O for 10 min and 25 cm H₂O for 5 min intervals then returned to baseline (n=21) (Appendix B & C)</p> <p>Control (C): Baseline ABG, increase PEEP for 30 seconds of sustained inflation at 30 cm H₂O with a 2-minute pause then repeat, maintain on previous vent settings with PEEP 10 cm H₂O for 1 hour (n=22) (See Appendix 4)</p>		<p>When designated to (I) or (C) exposures were applied via algorithms which were used to assist clinicians with donor management and data collection during the perioperative period and maintained until recovery. Exposure effect assessed by P: F ratio of ABG drawn at three points</p>	N= 43	<p>Overall lungs transplanted per donor between cohorts:</p> <ol style="list-style-type: none"> 1. Comparison of lung transplant rates within cohorts 2. P: F changes over time 3. P: F > 300 after 5 hours from baseline <p>Key scope for the study, and inclusion criteria was developed by the OPO in collaboration with donor hospitals, transplant centers, pulmonologists, medical director and the medical committee</p>	<p>Both methods demonstrated increased lungs transplanted per donor when compared to the national average (48% vs 20%; P<0.05):</p> <ol style="list-style-type: none"> 1. No differences ([I] 38.1% and [C] 54.5% patients where lung donors [p=0.28; NS]) 2. Both groups had significant increases in P: F ratio from baseline to 30 minutes (p<0.01); [I] increased by 46.4 [94.1] units [p=0.04] (C) increased by 71.8 (67.4) units (p<0.001) 3. No differences in P: F between the two over time ([I] 33.3% and [C] 40.9% donors had P:

TABLE 1 – *Continued*

Author/Article	Qual: Concepts or Phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
						<p>F ratios > 300 at 5 hours from baseline [p = 0.44; NS])</p> <p>No true control group and small sample size – study lacks power; would have improved if there was a third arm control group that measured standard of care</p>
<p>Brügger, A., Aubert, J., & Piot-Ziegler, C. (2014). Emotions while awaiting lung transplantation: A comprehensive qualitative analysis. <i>Health Psychology Open</i>, 1(1), 1-29</p>	<p>Exploration of theoretical samples of experience and emotions of patients with debilitating physical illnesses including transplant to provide patients and clinicians with a comprehensive report of potential lung recipients emotional descriptions prior to being transplanted</p>	<p>Interview: Material focused on inductive reasoning, of topics relating to patient's experience of transplantation and emotions</p> <p>Emotion dialogue based on theoretical evaluations and categorized by positive, negative and neutral</p>	<p>Qualitative</p> <p>Convenience sample of transplant group needing lung(s) recruited from 2 clinics from February 2010 - January 2012</p>	<p>N= 16</p>	<p>Voice recorded semi-structured interviews with open questions: creative interviewing that were concluded upon saturation</p> <p>Assessment of interactive strategies for engagement</p>	<p>By achieving a better understanding of the complexity of emotions endured by listed patients, clinicians can promote a better description to the donor families of the physical and emotional state of the transplant recipient</p>

TABLE 1 – *Continued*

Author/Article	Qual: Concepts or Phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
						Strategies by which clinician and patient participate in interactions regulate emotional adaptation in the process
Courtwright, A. & Cantu, E. (2017). Evaluation and management of the potential lung donor. <i>Clinics in Chest Medicine</i> , 38, 751-759	Evaluation of patient-related and organ-related risk factors impact on post-transplantation allograft function. Focus on the state of donor and donor lung assessment strategies and techniques for lung preservation in the preoperative period		Descriptive report on lung assessment strategies and techniques for lung preservation in perioperative period	N= Not stated	<ol style="list-style-type: none"> 1. Evaluation of lung donor 2. Recipient prognosis based on acceptable rather than ideal 3. Lung donor management 4. Lung perfusion prior to transplant 	<ol style="list-style-type: none"> 1. Ideal Donor: <55 years age, <20 pack-year smoking, no sig medical history, evidence of pulmonary disease, P: F ratio > 300, appropriate size matching; Acceptable: >65 years age <40 pack-year ever, diabetes and other chronic disease, lack of multidrug-resistant infection, P: F ratio > 200, between 0.9 and 1.3 predicted total lung capacity

TABLE 1 – *Continued*

Author/Article	Qual: Concepts or Phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
						<p>2. There is no significant negative impact on recipient prognosis on any single factor that makes a donor rather than ideal</p> <p>3. After Brain death donor management should focus on protocol-driven means of optimization of pulmonary physiologic factors</p> <p>4. Ex vivo lung condition perfusion may be an alternative for lungs that would otherwise not meet transplant criteria</p> <p>Descriptive report without a validated tool describing methods. There are likely recipient factors that make</p>

TABLE 1 – *Continued*

Author/Article	Qual: Concepts or Phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
						transplant from a marginal donor significantly riskier and without evidence of donor-recipient combination risk tool, it is hard to make solid conclusions
Dikdan, G. S., Mora-Esteves, C., & Koneru, B. (2012). Review of randomized clinical trials of donor management and organ preservation in deceased donors: Opportunities and issues. <i>Transplantation</i> , 94(5), 425-441	Broad goals of donor management of donors after Brain death include: 1. Maintenance of optimal circulatory and metabolic state 2. Evaluation and improvement or maintenance of organ function 3. Maximization of organs transplanted per donor 4. Improvement of graft quality		Systematic review of RCTs using MEDLINE, Cochrane Library, Google Docs, Clinical Trials.gov and BioMed Central databases using keywords Grouped into: a. Donor Management b. Preservation Fluids c. Machine Perfusion	N= 87 total, 32 informing PICO(T)	Donor management Categorized: 1. Hormone replacement, hemodynamics and fluid management (n=13) 2. Immunosuppressants and preconditioning (n=19) Omitted: 3. Preservation fluids (n=34) 4. Pulsatile perfusion (n=21)	1. Use of vasopressin as part of hormonal therapy increased the number of organs recovered thus should be used in routine management; thyroid hormone has no effect on donor hemodynamics, organ recovery or function; Hydroxyethyl starch increased serum creatinine and need for dialysis 2. Steroids have not improved primary

TABLE 1 – *Continued*

Author/Article	Qual: Concepts or Phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
						<p>endpoint of P: F ratio. Despite this one study and based on other findings authors recommend use of steroids in lung donors as adjunct to active donor management</p> <p>More funding is needed. Protective ventilatory strategy in potential organ donors and effect of nebulized albuterol on donor oxygenation are only prospective RCTs</p>
<p>Fan, E., Checkley, W., Stewart, T. E. Muscedere, J., Lesur, O., Granton, J. T., et al. (2012). Complications from recruitment maneuvers in patients with acute</p>	<p>Intervention (I): Sustained inflation RMs of CPAP 40 cm H₂O for 40 seconds with FiO₂ of 1.0 following ventilator disconnects.</p>	<p>Baseline severity of illness using Acute Physiology and Chronic Health Evaluation (APACHE) II score and severity</p>	<p>Retrospective analysis from a RCT</p> <p>Secondary analysis from a single method RCT of adult ALI patients that received one or more RMs from the</p>	<p>N= 475</p>	<p>Complications during RMs</p> <p>Classified: 1. Respiratory: desaturation (SpO₂ < 85% or a new air leak through an existing chest tube)</p>	<p>Complications were common (22% of patients receiving RMs)</p> <p>The number of RMs received was associated with increased risk in all</p>

TABLE 1 – *Continued*

Author/Article	Qual: Concepts or Phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
lung injury: Secondary analysis from the Lung Open Ventilation Study. Respiratory Care, 57(11), 1842-184	Repeated up to four RMs daily Control (C): Patients receiving 1 < RMs with P: F < 250 during invasive mechanical ventilation		patients with ALI enrolled in the multicenter Lung Open Ventilation Study patients in 30 intensive care units in Canada, Australia, and Saudi Arabia		2. Cardiovascular: complications (HR <60 or > 140 b/m, MAP < 60 mm Hg, or new arrhythmias)	age groups; 2 RMs odds ration [OR] 6.92 (95% CI 1.7-28.2), > 2 RMs OR 15.4 (95% CI 4.77-49.6) Association between the number of RMs received and complications after controlling for illness severity and duration; most occurred < 7-d of enrolment and among patients with pulmonary complications versus extra-pulmonary ALI (26% vs 14%; P=0.006). No differences in mortality/morbidity

TABLE 1 – *Continued*

Author/Article	Qual: Concepts or Phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
						<p>However, had several flaws: There were a greater portion of Extrapulmonary ALI in the group that did not develop complications from RMs (41% vs 24%, P=0.006)</p> <p>Although complications were common, serious complications (e.g. new air leak through an existing chest tube) were infrequent and the duration of the primary events was not recorded thus may have been transient</p>

TABLE 1 – *Continued*

Author/Article	Qual: Concepts or Phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
<p>Hanna, K., Seder, C. W., Weinberger, J. B., Sills, P. A., Hagan, M., & Janczyk, R. J. (2011). Airway pressure release ventilation and successful lung donation. <i>Archives of Surgery</i>, 146(3), 325-329</p>	<p>Intervention (I): Using APRV release rate of 6-10 breaths/min, inspiratory pressure of 20-25 cm H₂O, FiO₂ 0.4, settings determined and adjusted by the intensivist. Managed during timeframes with APRV (n=25)</p> <p>Control Group (C): AC mode rate 10-12 breaths/min, tidal volume 5-10 ml/kg, FiO₂ of 0.4, PEEP 5 cm H₂O. Managed with during timeframes with AC ventilation (n=20)</p>		<p>Nonrandomized clinical trial</p> <p>Retrospective, cross sectional analysis of case series involving consecutive donors between January 1st, 2003 – December 31st, 2008 that met criteria for potential lung donation in a private tertiary level I trauma center in Michigan</p>	N= 45	<p>Lungs transplanted per donor</p> <p>P: F changes over time</p> <p>Graft survival rates</p> <p>Secondary analysis of variables</p>	<p>Increased lung transplants ([C] 7 of 40 [18%] vs [I] 42 of 50 [84%], p<0.001)</p> <p>P: F admission were similar ([C] 334 ± 128 vs [I] 272 ± 127 [p=0.12]); and improved in the interventional arm (terminal: [C] 334 ± 104 versus [I] 498 ± 43 [p<0.001])</p> <p>No difference in graft survival rates ([C]) 71% alive at 36 months [I] 91% alive at 36 months [p=0.19])</p> <p>No differences in sex, cause of death, smoking hx, P: F ratio on admission, or ventilator time. However, mean age was less in the (I) 34</p>

TABLE 1 – *Continued*

Author/Article	Qual: Concepts or Phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
						<p>± 11 versus 41 ± 12 (C) ($p=0.05$)</p> <p>Mean age differences – nonhomogenous group could have contributed to gains, especially since (I) group was within lower age range of highest rates of transplant</p> <p>Selection bias – Transition between AC to APRV showed early signs of improved outcomes, thus was used more frequently</p>
Kirschbaum, C. E. (2010). Increasing organ yield through a lung management protocol. <i>Progress in Transplantation</i> , 20(1), 28-3	Intervention (I): Per treatment protocol – per Gift of Life Michigan OPO using two types of ventilator settings		Nonrandomized clinical trial Comparative, retrospective PDSA brain dead donors	N= Not disclosed	Lungs transplantable per donor as measured by PaO ₂ and expressed by PaO ₂ / FiO ₂ ratio (P: F)	Increased lungs transplantable per donor from 66.0% (C) to 83.7% (I) protocol

TABLE 1 – *Continued*

Author/Article	Qual: Concepts or Phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
	<p>AC and PC with PEEP maneuver of CPAP of 40 cm H₂O for 30 seconds repeated every 20 minutes for a total of 3 cycles</p> <p>Control (C): Lung transplants occurring from 2003 – 2004 prior to intervention</p>		<p>from ages 15-60 evaluated on a case-by-case basis from 9/2005 – 12/2008. Lungs considered transplantable had a PaO₂ > 300 mm Hg on admission in Michigan</p>		<p>Raw number of lungs transplanted over 4-years</p> <p>Organs transplanted per donor</p>	<p>Increased from 135 (265% improvement) over 4 years</p> <p>Increased from 3.59 (C) to 3.9 (I) (p=0.03)</p>
<p>Mascia, L., Pasero, D., Slutsky, A. S., Arguis, M. J., Berardino, M., Grasso, S., ... Ranieri, M. V. (2010). Effect of a lung protective strategy for organ donors on eligibility and availability of lungs for transplantation: A randomized controlled trial.</p>	<p>Intervention (I): Ventilation with V_t of 6 – 8 mL/kg IBW and PEEP of 8 – 10 cm H₂O and closed circuit tracheal suction and apnea testing with CPAP (n=59)</p> <p>Control (C): Ventilation with V_t of 10 – 12 mL/kg IBW and PEEP of 3 – 5 cm H₂O and open circuit tracheal</p>		<p>Multicenter RCT</p> <p>Central computer-generated block randomization to either arm of potential donors between September 2004 – May 2009</p> <p>When designated to (I) or (C) exposures were applied during a 6-hour period of observation essential for Brain death declaration and</p>	<p>N = 118</p>	<p>Exposure effect assessed by P: F ratio of ABG drawn at three points</p> <p>Lung eligibility, as defined: P: F ratio > 300 on FiO₂ 1.0 and peak airway pressure < 30 cm H₂O concluding the 6-hour observation period:</p> <ol style="list-style-type: none"> Number of patients whose lungs were recovered Number of patients 	<p>Eligibility: 56 (95%) of (I) versus 32 (54%) in (C) (difference of 41% [95% CI 26.5 to 54.8%]; P<0.001)</p> <ol style="list-style-type: none"> (I) 32 (54%) versus (C) 16 (27%) (difference of 27% [95% CI, 10.0% to 44.5%]; P=0.004) No difference Baseline P: F ratio was equal between groups pre-

TABLE 1 – *Continued*

Author/Article	Qual: Concepts or Phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
JAMMA, 304(23), 2620-2627	suction and apnea testing (n=59)		maintained until recovery		who received lung transplants who were alive at 6-months. 3. Change in P: F ratio	<p>intervention (208 ± 83 [C] vs 224 ± 47 [I] [difference of 16; 95% CI, -86 to 116]). After the 6-hour period improved in (C) and (I) (454 ± 76 vs 491 ± 115 [difference of 37; 95% CI, -8 to 82]; p=NS)</p> <p>The steering committee stopped the study before the planned interim analysis because of funding but did not have knowledge of the outcomes before decision was made</p> <p>Although the hypothesis was validated through the study measures, the construct demonstrated discrepancies between eligible and</p>

TABLE 1 – *Continued*

Author/Article	Qual: Concepts or Phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
						actual donor rates (number of patients meeting lung donor eligibility for [I] = 56 [95%] and only 32 [54%] were actually transplanted; vs [C] = 32 [54%] were considered eligible and 16 [27%] were transplanted)
Noiseux, N., Nguyen, B. K., Marsolais, P., Dupont, J., Simard, L., Houde, I., et al. (2009). Pulmonary recruitment protocol for organ donors: A new strategy to improve the rate of lung utilization. <i>Transplantation Proceedings</i> , 41(2), 3284-3289	Intervention (I): Treatment Protocol for lung recruitment Involving: Baseline ABG, Increasing PEEP for 30 seconds of sustained inflation at 30 cm H ₂ O with a 2-minute pause then repeat Control (C): Management per protocol prior to treatment protocol (2004 -2005; n=272)		Nonrandomized continuous data trial of a treatment protocol Quantitative, retrospective, cross sectional analysis comparison of a protocol applied to multi-organ donors unless lungs not being considered for underlying diseases processes from 2006 – 2008	N= 430	Annual lungs transplanted per donor-year comparison Change in P: F means within cohort (I)	Lung transplant rates increased from: 1. 2006 - 20% (C) to 33%. 2. 2007 - 20% (C) to 24%. 3. 2008 - 20% (C) to 24 Improvement in > 15% P: F ratio (P<0.05)

TABLE 1 – *Continued*

Author/Article	Qual: Concepts or Phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
Rech, T. H., Moraes, R. B., Daisy, C., Czepielewski, M. A., & Leitao, C. B. (2013). Management of the brain dead organ donor: A systematic review and meta-analysis. <i>Transplantation</i> , 95(7), 966-974	To develop updated recommendations and a clinical practice guideline for perioperative management interventions to stabilize hemodynamics, to improve organ function and outcomes of transplantation in brain dead donors		Systematic review Using Medline, Embase, and Cochrane databases using a detailed search strategy involving English-language literature of primary trials in donor management and organ preservation Categorized: 1. Hemodynamics 2. Fluid management 3. Qualitatively graded single intervention strategies	N= 39 RCT's Of 5096 articles retrieved, 20 included in a qualitative synthesis providing data on 1277 patients. Of the 20, 12 could not be categorized because they were single interventions and 8 were included in the meta-analysis	Independent evaluated by two reviewers, disagreements were solved by consensus of third reviewer. Risk of bias was based on GRADE analysis. Key questions, the scope for the study, and inclusion criteria was developed by the researchers. 1. Vasopressor and hormone replacement therapy (n=264 patients from 6 studies) 2. Fluid type and balance (n=33 patients from 2 studies) 3. Mechanical ventilation strategies (n=118 patients)	1. Use of triiodothyronine (T3) inconsistent thus withhold until further trials; desmopressin was not associated with better kidney graft outcomes; Methylprednisolone promoted hemodynamic stability; Unclear most efficacious vasopressor but likely norepinephrine over dopamine 2. No evidence to support use of hydroxyethyl starch; use of colloids is an option to avoid infusion of large volumes and protect lung grafts 3. Best evidence in management refers to mechanical ventilation using lung protective strategies

As discussed in the lung recruitment section and shown above, there had been multiple interventional trials demonstrating improved transplant rates using both recruitment methods (e.g., NCRMs & CRMs). However, a systematic review of the literature by Dikdan, Moraes-Esteves and Koneru (2012) didn't show enough high-grade evidence to make sound recommendations for any specific method. In another meta-analysis, Rech, Moraes, Crispim, Czepielewski and Leitao (2013) stated, "the use of lung protective strategies with low tidal volumes increases the yield of lungs when compared with conventional strategies" (as cited by Mascia et al., 2010, p. 972). Collectively, these meta-analyses highlighted a wide variability in techniques and the lack of published high quality and grade clinical trials to offer recommendations as to which method was the most efficient. Additionally, both publications suggested that alveolar recruitment maneuvers were likely an effective treatment method to improve P: F ratio and LTPD.

From the dates these meta-analyses were published, there was only one multi-centered RCT (Mascia et al. 2010) that was pertinent to the PICO question. Moreover, in 2018, this author published data from a similar PDSA design as Mascia's in that both were multicenter, RCTs; only this study compared two NCRM's (CPAP vs. Step-Up PEAK) and Mascia's compared a CRM to Assist Control ventilation. Both methods demonstrated increased LTPD when compared to the national average of 21% (48% in Bergstrom's trial, $p < .05$; 54% in Mascia's, $p < .05$). There was concern that these CPAP techniques did not positively impact ventilator-induced lung injury (as cited by Fan et al., 2012); however, most reports were found in the literature to have varying degrees of positive outcomes (Table 1). To summarize, the combination of NCRM trials suggested that knowing the upper-pressure limits and cycle frequencies were important but

undefined and perhaps dynamic. The CRM trials were collectively interpreted as methods using larger MAPs with lower PIPs, that could be accomplished in several ways and which method was most efficacious was undefined.

METHODS

The objective of the DNAZ Ventilatory Management Goals (Figure 3) was to serve as a tool to achieve an arterial blood gas P: F > 300 and pH values between 7.3 and 7.5, which reflected the merits of the DMGs. Treatment of hypoxemia (defined as a P: F ratio < 350), involved applying alveolar recruitment maneuvers (Appendices B, C, & D) until the P: F ratio was > 350 or if the donor became hemodynamically unstable.

Peak inspiratory pressures (PIP)	< 35 cmH ₂ O
Plateau Pressure	< 30 cmH ₂ O
Rate	Adjust to maintain PaCO ₂ 35-45 mmHg and pH 7.3 - 7.5
PEEP	Maintain PEEP of 5 cmH ₂ O when making offers
Peak Flow	To achieve an <u>I:E</u> ratio of 1:1, 2:1, 4:1, or > to achieve P:F
P/F Ratio	> 350 on FiO ₂ 40 % and 100 %
SpO ₂	> 97 %

* PBW – Predicted Body Weight

FIGURE 3. Donor network of Arizona ventilator management goals. (Bergstrom, Khanna, Muriette & Wallia, (2015). Donor Network of Arizona Clinical Practice Guidelines: Donor Network of Arizona Ventilatory Management Goals (Section 6.4.11 of the Clinical Practice Guidelines)

An hour-long educational activity using a PowerPoint Presentation (Appendix E) was performed and based on the information gathered from the needs assessment questionnaire (Figure 5) on transplant clinician's experiences with the recruitment maneuvers and Ventilatory Management Goals. Shortly after that, a post-activity evaluation form (Figure 6) was completed by the attendees to report the participants' perceptions of the effectiveness of the intervention. A comparison between organ donor type, DMGs and OTPD were made two months after the

educational intervention (from December 1, 2018 – January 31, 2019) and the results disseminated.

The mode, of administering the questions that guided the educational intervention involved entering the pre-evaluation needs assessment questionnaire information into Qualtrics and issuing them via email to the transplant clinicians. After the presentation and with permission from the author, a modification of a standardized evaluation form graded the presentation for content, clarity, and applicability to practice. These forms were printed and handed out after the performance and data was manually entered into Qualtrics for evaluation.

Design

A single group of transplant clinicians completed electronically issued and recorded questionnaires to inform the educational needs for ventilator management and lung recruitment strategies in donor patients. The development of both forms (i.e., needs assessment questionnaire & evaluation form) (Figures 6 & 7) were modifications of a well-validated assessment tool used by the American Board for Transplant Certification (ABTC) to award a Continuing Education Point for Transplant Certification (CEPTC) corresponding to a one-hour educational forum. Both inquiries were anonymous, and the question items explored the reasoning of missing the DMGs for the interventions listed in the organization's CPGs. A convenience sample (n=25) of transplant clinicians that attended the required monthly staff meeting held on November 29, 2018 in Phoenix, AZ reported the perceptions of the education intervention (Appendix E). The frequencies and distributions of reported practice changes this event sought to make were obtained by gathering the data that transplant clinicians entered into the evaluation form. The open-ended questions, which were a part of the evaluation form, were reported to the ABTC

board by the educator and not here to preserve respondent's confidentiality. This study would have been improved if these results had been reported as examples of qualitative data extracted to enrich the overall picture of what was learned about this intervention without compromising the identity of the participants. However, that data was kept internal between the leadership of DNAZ and the ABTC accrediting body.

Two months following the education intervention, sustainability, and efficacy of the session were assessed by a retrospective chart review and by using the gap analysis tool that compared O: E of the percent of lung donors, as compared to national trends and OTPD among donors that; (1) met seven DMGs, (2) those that did not, and (3) the total of those two values combined (Table 4).

Setting

The federally designated nonprofit OPO DNAZ covered the entire state of AZ in its diagnostic service area. The organization's mission was to "make the most of life through the gift of organ and tissue donation: their vision was to "challenge our[them]selves and others every day to realize Arizona's potential to save and improve lives." In the critical care unit, where the organ donor was pronounced dead by neurological criteria, clinical decisions for the medical management of that donor were in concert with OPOs mission and vision, which consisted of a collaborative team approach. Along with direction provided by their Medical Director and input from the Organ Team Lead, much of the judgment of donor management relied on the onsite transplant clinicians who were encouraged by organizational policy to use the Adult Organ Donor Management Guidelines as a tool to implement interventions.

The large diagnostic service area of DNAZ called for transplant clinicians to have direct contact with each other during the mandatory monthly staff meetings to discuss topics and review clinical practice changes. The staff meetings were inclusive of the transplant clinicians, which were this project's target population. The presence of the population was mandatory unless working and the number of attendees was 25. The expectation was 100% of the participants would complete the post-interventional questionnaire. This goal was achieved by comparing transplant clinicians that had signed in on the morning of the meeting and had remained present throughout the presentation to the number of respondents.

Participants

Transplant clinicians employed at DNAZ who were involved in the medical management of brain dead organ donors were the primary target of the assessment, intervention, and evaluation of this project. Of note, to simplify the otherwise vast number of titles and roles of clinical personnel, Organ Recovery Coordinators, Administrators on Call, Organ Team Lead, and Clinical Risk-Managers were used synonymously with "transplant clinicians," who were the respondents of this survey. Other common terminology used for similar clinical roles included; Procurement Transplant Coordinators, Advanced Practice Coordinators, Transplant Coordinators, Clinical Transplant Coordinators and more.

Intervention

Following the Iowa Model of EBP (2017) (Figure 2), the problem focus trigger as it related to lung donor management at DNAZ involved the shortcoming of meeting the benchmark of the DMGs and OTPD at the end of the second quarter of 2018. The expected OTPD of the donors that didn't meet the DMGs had a gap of -1.48 (expected 3.09 vs. actual 1.61). The

transplant clinicians' perceptions (such as normal practice habit, safety, and barriers or limitations to their efficacy) of three lung management regimes in the organization's CPGs were explored to identify the possible etiology of this odds ratio gap. Means to achieve these metrics without increasing harm or creating significant interruptions in workflow while meeting DNAZ's organizational priorities was sought to minimize negative thinking.

During portions of the educational intervention frequency distributions and rankings of the electronically recorded responses were displayed and topics involving the objective sections of the evaluation form were discussed (Figure 6 & Appendix E). Without evidence, implications are often approached by clinicians with skepticism and therefore a comparison between the local results of the PDSA cycles performed at DNAZ was displayed so that clinicians could judge the techniques that were both based on published data and also from their own clinician experiences (Figure 4). As demonstrated, there was an increase in both lung transplant rates (63% vs. 48%) and P: F (34% vs. 0%) in the second stage whereas the overall transplant rates were similar between stages (4.72 vs. 4.42). The delta P: F compared the arterial blood gas drawn prior to the alveolar recruitment maneuver to the blood gas obtained four-hours after the intervention according to the algorithmic protocols (Appendices B, C, & D). Conclusions of the assessment were disseminated through visual displays as follows: frequency histograms displayed graded questions, and bar charts showed the percent of respondents selecting each choice. The contents of the educational intervention can be seen in Appendix E.

COMPARISON BETWEEN STAGES

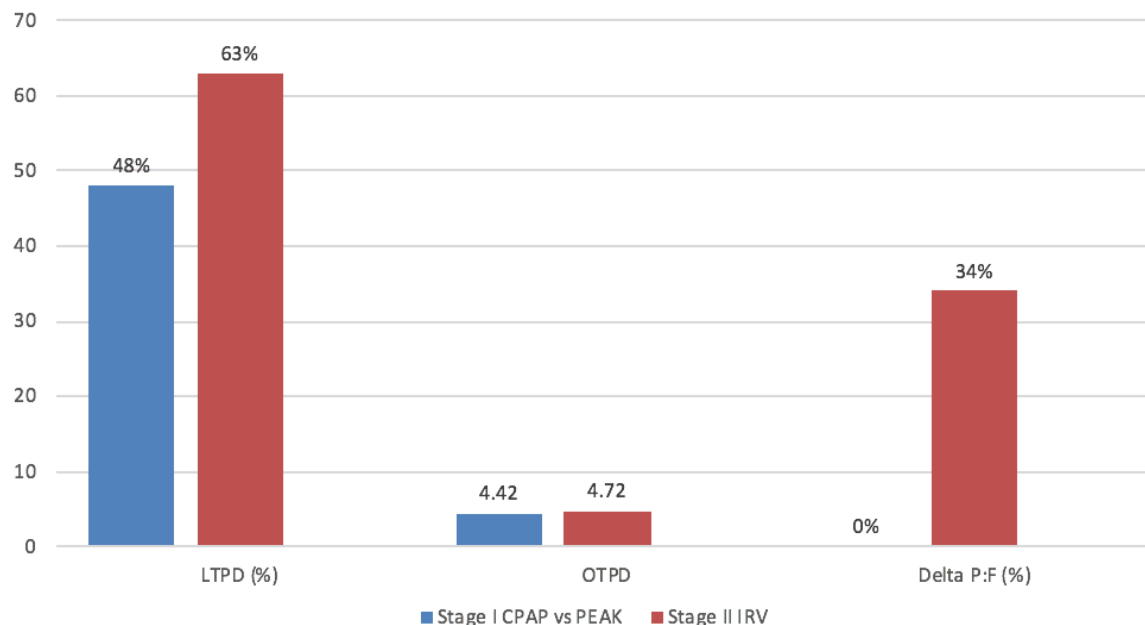


FIGURE 4. Comparison between Plan-Do-Study-Act (PDSA) stages. IRV: Inverse ratio ventilation. Percentages (%) expressed as donors who met inclusion criteria. LTPD = Lungs Transplanted per Donor; OTPD = Organs Transplanted per Donor; IRV = Inverse Ratio Ventilation; CPAP = Continuous Positive Airway Pressure; P: F = Partial pressure of arterial oxygenation (P) to fraction of inspired oxygen (F) ratio

Data Collection

Both assessments (i.e., needs assessment questionnaire and evaluation form) were held anonymous to avoid identifying responses. Questions were scaled 1-4 (1 = the greatest; 4 = the worst) and based on the degree of agreement by the statement. Other inquiries compared the three techniques in the CPGs by ranking them 1-4 (4 = “Other Method”) (Figure 5). Following the presentation, the evaluation questionnaire was issued, collected, recorded, and entered into Qualtrics by the Clinical Educator (Figure 6). Through retrospective chart reviews two months after the educational intervention (December 2018 - January 2019) DMGs and OTPD were collected electronically through a built-in system that DNAZ had contained within their electronic medical record system.

Donor Network of Arizona
Needs Assessment Form

Directions: Please evaluate the needs for this course using the following rating: 1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree	SD	D	A	SA
A review of the lung recruitment maneuvers in our Clinical Practice Guidelines (CPGs) would likely help improve my comfort level when managing the potential lung donor.	1	2	3	4
There is need for an education intervention to inform the physiology of the recruitment maneuvers in our CPGs to achieve a better understanding.	1	2	3	4
Meeting the metrics of DMGs and lungs transplanted per donor is an important part of if/not I choose to perform a lung recruitment maneuver	1	2	3	4
If provided with sufficient evidence suggesting that a practice improves DMGs met and/or lungs transplanted per donor that differed from my current practice, I would change my methods of recruitment?	1	2	3	4
Using the recruitment maneuvers in our CPGs provide effective means to increase lungs transplanted per donor.	1	2	3	4
The screening tool algorithms are useful components in applying recruitment maneuvers in real time.	1	2	3	4
I know when and how to perform the recruitment maneuvers in the CPGs.	1	2	3	4
In terms of efficacy, there are significant differences between each of the maneuvers.	1	2	3	4
I perform lung recruitment maneuvers according to our CPGs	1	2	3	4
I avoid using the methods of lung recruitment listed in the Clinical Practice Guidelines (if so, please write reason):	1	2	3	4
Directions: Please rank the following recruitment maneuvers in order from 1-4 (1=meaning most; 4=least) using each number only <u>ONCE</u> for each question.				
Comfort level in performing intervention	Step-up PEAK	CPAP 30 cm H2O	Inverse Ratio (APRV)	Other methods
Efficacy in achieving more DMGs/lungs transplanted per donor				
A safer mode of lung recruitment				
Familiarity				
Has the greatest barriers to implementation (buy-in, push-back, or other things limiting ability to perform).				

FIGURE 5. Donor network of Arizona needs assessment form.

Donor Network of Arizona
Evaluation Form

Name of Participant: _____

Date: _____ Location: Donor Network of Arizona, Phoenix, AZ

As a result of this activity, please share at least one action you will take to change your professional practice; if your practice will not change list at least one reason why:					
The most valuable part of this project was:					
The activity could be improved by:					
Directions: Please evaluate this course using the following rating: 1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree					
	SD	D	A	SA	
The speaker was knowledgeable about the topic and provided the information in an interesting manner that facilitated my learning.	1	2	3	4	
Speaker: Ben Bergstrom, RN, BSN, CCRN, CPTC, SRNA					
This presentation changed my perceptions of the recruitment maneuvers in the DNAZ Clinical Practice Guidelines.	1	2	3	4	
This presentation improved my comfort level and safety when applying the recruitment maneuvers in the Clinical Practice Guidelines.	1	2	3	4	
I found this activity worthwhile for my professional practice. (If you select “Disagree” or “Strongly Disagree” please provide a comment below):	1	2	3	4	
This activity will enhance my knowledge/skill as a procurement professional:	1	2	3	4	
The overall objective for this course presentation was met: In this interactive and thought provoking introductory training, participants will learn the basic components of determining the interventional needs and relationships between applied models of evidence-based practice, clinical practice guidelines and choice of donor management strategy. Trainees will be able to identify factors that influence the intervention as well as strategies to overcome barriers in an effort to mutually achieve acceptable goals that will increase transplantable organs.	1	2	3	4	
After attending this course, to what extent do you feel prepared to meet the following objectives:	SD	D	A	SA	
Objective 1	The attendees will identify local and national needs for lung transplant, and the gaps.	1	2	3	4
Objective 2	The learner will describe how Brain death negatively affects organ function and methods used to mitigate those physiologic responses.	1	2	3	4
Objective 3	The Transplant Clinician will be able to cite endpoints of lung management and methods to achieve those endpoints.	1	2	3	4
Objective 4	The participant will be able to compare and contrast methods and limitations of recruitment maneuvers in the literature and their current practice.	1	2	3	4
Objective 5	The learner will be able to judge how this in-service will/will not change his/her practice.	1	2	3	4
Please rate the extent to which your personal questions and concerns were answered.					
		1	2	3	4
The content of this topic was free from commercial bias.			Yes	No	
I was able to complete the online Needs Assessment questionnaire			Yes	No	
Additional Comments:					
Suggestions for education topics:					

FIGURE 6. Donor network of Arizona evaluation form.

Data Analysis

A content analysis of the recorded needs assessment questionnaires focused on identifying the attitudes, perceptions, and knowledge of the recruitment maneuvers as experienced and perceived by the transplant clinicians and their application to meeting DMGs. The Qualtrics Experience Management software program was the workbench used to gather and display the data. The package made available to the principal investigator through the University of Arizona provided the means that helped arrange, reassemble and manage data into useful information. Mutually exclusive classes were used to divide the data, and frequency distributions and grading were displayed utilizing univariate frequency tables that ranked the degree of agreement from '1' = *Strongly Agree* to '4' = *Strongly Disagree* and the number of occurrences in each class. This method was also used in the evaluation of the intervention (Tables 2 & 3).

The efficacy of the in-service was assessed using a gap analysis of the OTPD and percentage DMG's met in donors from two months before the presentation (10/01/2018 to 11/29/2018) which served as the control group (n=31), to those reached two months after the education intervention (11/30/2018 to 01/31/2019) which served as the study sample (n=34). These data were to be gathered by retrospective chart reviews. The number of OTPD were further broken down into the percent in each sample that became lung donors (i.e., LTPD) and compared them to the national average of 21%. Frequencies of donors who met at least seven DMGs were reported as percentages whereas an independent paired t-test compared the means of the OTPD. Statistical significance was determined by $p < .05$. Ideally all three metrics; (1) OTPD, (2) LTPD, and (3) DMGs would improve as a result of the EBP in-service that focused on methods to achieve these metrics.

Resources and Budget

The cost was contained internally and most of the resources involved obtaining the time allotted for the intervention held during the staff meeting. The Qualtrics system was included in the investigator's tuition costs and informed the results for no additional charge while the remaining members dedicated no more than a standard eight-hour shift broken up over the timeframe of the project. For example, the Educator reviewed educational material and input data through Qualtrics. Buy-in from DNAZ committee leadership was needed to allocate the time required to deliver the presentation, explore the data, and to develop the questionnaires issued to the respondents. Barriers to designing and implementing the educational module were multifactorial, and the first challenge involved gaining a better understanding of the specific needs for this learning event. The size of the diagnostic service area of DNAZ necessitated that the staff questionnaires were issued and recorded electronically (See Methods). Furthermore, Rycroft-Malone and Bucknall (2010) suggested expecting a 30-40% response rate when sending internal questionnaires, and this would be problematic considering there were only 31 transplant clinicians at the time of the assessment. Finally, creating a presentation that captured all the pertinent points in the needs assessment questionnaire and did not exceed an hour timeframe was a challenge, as was keeping within the OPOs accrediting body guidelines.

Ethical Considerations

Ethical considerations involved in this project included: (1) *Respect for Persons*, (2) *Beneficence*, (3) and *Justice* (USDHHA, 1979).

Respect for Persons

Informed consent was used to provide information, comprehension, and voluntariness of each participant. In this project, transplant clinicians were able to voice their perceptions, concerns, and needs for a tailored education intervention informing recruitment maneuver strategies. A Disclosure of Determination for Research was provided (Appendix E), and the Qualtrics program function assured anonymity was maintained when reporting respondents of the pre-education and evaluation of the intervention. Anonymity was essential to prevent negative perceptions or harm to the participants, and each participant was made aware of security measures in place to protect their confidentiality.

Beneficence

In this project, dissemination of physiologic information regarding lung recruitment maneuvers was a balance between doing good for the organ donor while avoiding harm. By providing information to transplant clinicians on how to prevent injury by using these lung recruitment methods, success was assumed to be the result as measured by improving the number of DMGs met and lung transplant rates following the intervention.

Justice

Information and data were made available to all employees through the organization's intranet portal and during the meeting minutes thereby addressing justice and ethics. The material in the organization's CPGs was assessed annually, which was a standard operating procedure, and the updated version will include the algorithms in a section (Figure 7).

RESULTS

Needs Assessment

Obstacles to changing the practice of transplant clinicians were anticipated and thought to be related to comfort level, efficacy, safety and barriers to implementing alveolar recruitment maneuvers as a part of their donor management plan. Therefore, creating inquiries that sought viewpoints of the theoretical foundations of this project was necessary and done so by looking through the lenses of empirical knowledge in addition to an applied practice in theory. These questions assessed the need of a review of the evidence supporting the CPG as a useful tool for its ability to increase lung transplant rates and DMGs met, as well as transplant clinician's willingness to change from their practices. Of the 31 transplant clinician staff issued the needs assessment questionnaire there were 20 ($20/31 = 65\%$) that responded. Based on the respondents 90% "Agreed" that a review of the lung recruitment maneuvers in the CPGs would improve comfort levels when managing the potential lung donor (Table 2). Another 85% "Agreed" that there was a need for the educational intervention to inform the physiology of each maneuver and 80% indicated that meeting DMGs and LTPD was an essential part of whether they chose to perform an intervention.

Ranking from 1-4 determined the degree of agreement to assess transplant clinicians "willingness to change," and all but one of the respondents agreed with this statement, if provided with adequate data (Table 2). In other words, all but one transplant clinician reported their willingness to change. Because only 30% ($n=6/20$) of the participants indicated they "Strongly Agreed" to routinely performing alveolar recruitment maneuvers according to DNAZ CPGs, an assessment of confounding variables was warranted. Of the other variables identified

before the educational intervention and perhaps the most leading statistic was that only 15% (3 of 20) of the respondents assumed significant differences between maneuvers regarding efficacy. This deficit fueled the need to explore the literature (Appendix E) and to compare it to our local data. By employing a CRM method known as airway pressure release ventilation (APRV) to a continuous sample of donors (n=45) over a five-year span, Hanna, Seder, Weinberger, Hagan, and Janczyk's (2011) reported a technique that demonstrated the most substantial increase in LTPD in the literature, reporting gains from 18% in the pre-treatment to 84% post-interventional group, $p < .001$ (Table 1). Therefore, Hanna's (2011) methodology served as the evidence for a comparison between the second PDSA at DNAZ trialed in 2014 (Appendix D). The second stage of DNAZ's PDSA used IRV (similar mechanisms as APRV used by Hanna), and that data showed an overall lung utilization rate of 63% which was an improvement from the 48% yielded from the first PDSA comparing CPAP versus Step-up PEEP (Figure 4).

TABLE 2. Needs assessment results.

*Directions: Please evaluate the needs for this course using the following rating: 1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree	SD	D	A	SA
A review of the lung recruitment maneuvers in our Clinical Practice Guidelines (CPGs) would likely help improve my comfort level when managing the potential lung donor.	10% (2)	0	65% (13)	25% (5)
There is a need for an educational intervention to inform the physiology of the recruitment maneuvers in our CPGs in order to achieve a better understanding.	5% (1)	10% (2)	65% (13)	20% (4)
Meeting the metrics of (Donor Management Guidelines) DMGs and lungs transplanted per donor is an important part of if/not I choose to perform an alveolar recruitment maneuver.	0	20% (4)	40% (8)	40% (8)
If provided with sufficient evidence suggesting that a practice improves DMGs met and/or lungs transplanted per donor that differed from my current practice, I would change my practice methods.	5% (1)	0	25% (5)	70% (14)
Using the recruitment maneuvers in our CPGs provide effective means to increase lungs transplanted per donor.	5% (1)	0	55% (11)	40% (8)
The screening tool algorithms are useful components in applying recruitment maneuvers in real time.	5% (1)	25% (5)	55% (11)	15% (3)
I know when and how to perform the recruitment maneuvers in the CPGs.	0	10% (2)	60% (12)	30% (6)
In terms of efficacy, there are significant differences between each of the maneuvers.	15% (3)	40% (8)	35% (7)	10% (2)
I routinely perform lung recruitment maneuvers according to our CPGs	15% (3)	5% (1)	50% (10)	30% (6)
I avoid using the methods of lung recruitment listed in the CPGs.	0	20% (4)	45% (9)	35% (7)
**Directions: Please rank the following recruitment maneuvers in order from 1-4 (1=meaning most; 4=least) using each number only ONCE for each question.	Step-up PEAK	CPAP 30 cm H2O	Inverse Ratio (APRV)	Other methods
Comfort level in performing intervention:	2.26 (±0.96)	2.74 (±0.85)	1.63 (±0.81)	3.37 (±1.04)
Efficacy in achieving more DMGs/lungs transplanted per donor:	2.62 (±0.81)	2.95 (±0.60)	1.16 (±0.49)	3.26 (±1.07)
A safer mode of lung recruitment:	2.17 (±0.69)	2.94 (±0.85)	1.61 (±0.95)	3.28 (±1.10)
Familiarity with performing:	2.26 (±0.91)	2.89 (±1.02)	1.63 (±0.74)	3.21 (±1.06)
Has the greatest barriers to implementation (buy-in, push-back, or other things limiting ability to perform):	2.06 (±0.70)	2.44 (±0.83)	1.94 (±1.13)	3.56 (±0.96)

*Reported as ratio (n=20); () – raw numbers

**Reported as Means; (±) – standard deviation

Needs Assessment Results

Other methods involved comparing recruitment maneuvers according to ranking. When comparing rankings between recruitment strategies the respondents indicated that IRV showed trends toward the most: (1) comfortable, (2) familiar, (3) efficient at achieving DMGs/LTPD, (4) and safest method of recruitment in the DNAZ CPGs (Table 2). Therefore, during the education intervention, special attention was focused on the tools available to guide both transplant clinicians and medical staff less familiar with APRV.

Evaluation of Teaching Intervention

To evaluate the presenter, presentation, and if the educational intervention was adequate, the evaluation form was issued and collected by the Educator of DNAZ after the PowerPoint presentation (Figure 6). Of the 25 responders, all but one (96%) “Strongly Agreed” that, “The speaker was knowledgeable about the topic and provided information in an interesting manner that facilitated learning” (Table 3). Concerning efficacy, when asked if respondents found the intervention worthwhile, 96% “Agreed or Strongly Agreed.” Overall, the goals met the purpose of the intervention, which was to improve the knowledge, attitudes, and utilization of the CPGs. For example, 96% had at “Agreed” to having an improved comfort level; and all respondents “Agreed” that the activity enhanced their knowledge and skill. Most of the other inquiries had positive evaluation marks with the *least* positive response for the question, “This presentation changed my perceptions of the recruitment maneuvers in the DNAZ Clinical Practice Guidelines.” Hindsight, this statistic could have been the tribute to those that have either been practicing according to the guidelines and therefore already had positive perceptions; or those

with negative ideations whose opinions have not changed. This was a study flaw, and future evaluations should look into delineating this sub-population.

The evaluation process was two-fold, for it to meet the standards of the ABTC credentialing body for CEPTCs, a list of objectives and an evaluation of achieving those objectives where required. Of the six goals in the educational intervention, the overall aim was to inform the necessary components of determining the interventional needs and relationships between applied models of EBP, CPGs, and choice of donor management strategy. Only one participant “Disagreed” with these aims, and the remaining indicated an improvement in their abilities to identify factors that influence the intervention as well as strategies to overcome barriers. Therefore, the assumption is that all but one participant thought the event was worthwhile.

TABLE 3. *Evaluation results.***Evaluation Results**

*Directions: Please evaluate this course using the following rating: 1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree		SD	D	A	SA
The speaker was knowledgeable about the topic and provided the information in an interesting manner that facilitated my learning.		0	0	4% (1)	96% (24)
Speaker: Ben Bergstrom, RN, BSN, CCRN, CPTC, SRNA					
This presentation changed my perceptions of the recruitment maneuvers in the DNAZ Clinical Practice Guidelines.		8% (2)	4% (1)	40% (10)	48% (12)
This presentation improved my comfort level and safety when applying the recruitment maneuvers in the Clinical Practice Guidelines.		0	4% (1)	60% (15)	36% (9)
I found this activity worthwhile for my professional practice. (If you select “Disagree” or “Strongly Disagree” please provide a comment below):		0	4% (1)	36% (9)	60% (15)
This activity will enhance my knowledge/skill as a procurement professional:		0	0	52% (13)	48% (12)
The overall objective for this course presentation was met: In this interactive and thought provoking introductory training, participants will learn the basic components of determining the interventional needs and relationships between applied models of evidence-based practice, clinical practice guidelines and choice of donor management strategy. Trainees will be able to identify factors that influence the intervention as well as strategies to overcome barriers in an effort to mutually achieve acceptable goals that will increase transplantable organs.		0	4% (1)	36% (9)	60% (15)
After attending this course, to what extent do you feel prepared to meet the following objectives:		SD	D	A	SA
Objective 1	The attendees will identify local and national needs for lung transplant, and the gaps.	0	0	32% (8)	68% (17)
Objective 2	The learner will describe how brain death negatively affects organ function and methods used to mitigate those physiologic responses.	0	0	28% (7)	72% (18)
Objective 3	The transplant clinician will be able to cite endpoints of lung management and methods to achieve those endpoints.	0	4% (1)	32% (8)	64% (16)
Objective 4	The participant will be able to compare and contrast methods and limitations of recruitment maneuvers in the literature and their current practice.	0	0	32% (8)	68% (17)
Objective 5	The learner will be able to judge how this in-service will/will not change his/her practice.	0	0	8% (2)	92% (23)

*Reported as ratio (n=25); () – raw numbers

Impact of Results on Practice

The evaluation form results informed the quality of the educational intervention (Table 3). Brain dead donors meeting seven or more DMGs were also evaluated in addition to lungs and OTPD to quantitatively appraise the intervention. Compared to a sample of donors two months prior to the educational intervention (e.g., October 1 – November 30, 2018; n = 31), there was an

improvement in overall OTPD (3.0 vs. 4.21; $p < .01$) in the study group (e.g., December 1, 2018 – January 31, 2019; $n = 34$). This finding was likely due to the contribution of increased lung utilization in the sample as evidence by a 15% increase in the total expected lung donors when compared to national trends (e.g., 21% LTPD). In the sample – the percent of lung donors meeting DMGs almost doubled when compared to the pre-intervention control group (52% vs. 29%) and an improvement of the gap by almost four-fold (31% vs. 8%) was reported. In the control group there was only a difference of 9% between lung donors meeting and not meeting DMGs; where in the sample there was 29%, indicating a linear relationship between meeting DMGs and improving LTPD. Lastly, the OTPD in the study sample who met the DMGs (expected 4.13 vs. observed 4.57, +0.44) owed to closing the gap of those not meeting them (expected 4.3 vs. observed 3.62, -0.68) where the OTPD in the pre-intervention group had a total gap of -0.95 (expected 3.95 vs. observed 3.0). The combination of these results highlighted the positive changes brought forth by this in-service.

However, this intervention failed to demonstrate an improved ratio of donors that met seven or more DMGs (58% pre-intervention control vs. 56% post-intervention sample). Additionally, there were no differences in the means of DMGs met out of the total of nine (control 7.19 ± 1.40 vs. sample 6.97 ± 1.32 ; $p = .25$). As demonstrated below (Table 4), the largest and most consistent gap in OTPD were seen in donors that didn't meet seven of nine DMGs (-1.76 control, -0.68 study). Additionally, there were gaps in OTPD observed in the pre-intervention group regardless if DMGs were met or not (-1.76 not met; -0.56 met) which as not a phenomenon observed in the study sample, where the only gap was observed in those not

meeting the DMGs (expected 4.3 vs. observed 3.62, -0.68). Increasing the number of donors in the sample, in addition to randomization would have made this project stronger.

TABLE 4. *Gap analysis.*

Gap Analysis							
Pre-intervention				Post-intervention			
Organs Transplanted per Donor and Donor Management Goals							
*Not Meeting DMGs	Lung Donors	OTPD	Type	**Not Meeting DMGs	Lung Donors	OTPD	Type
Expected	21%	3.76	SCD: 7	Expected	21%	4.3	SCD: 13
Observed	20%	2	ECD: 3	Observed	23%	3.62	ECD: 0
Gap	1%	1.76	n = 10	Gap	2%	0.68	n = 13
Meeting DMG				Meeting DMG			
Expected	21%	4.04	SCD: 18	Expected	21%	4.13	SCD: 19
Observed	29%	3.48	ECD: 3	Observed	52%	4.57	ECD: 2
Gap	8%	0.56	n = 21	Gap	31%	0.44	n = 21
Control Total				Sample Total			
Expected	21%	3.95	SCD: 28	Expected	21%	4.19	SCD: 32
Observed	26%	3.0	ECD: 6	Observed	41%	4.21	ECD: 2
Gap	5%	0.95	Total: 31	Gap	20%	0.02	Total: 34

Gap analysis between meeting Donor Management Goals (DMGs), percent (%) lung donors compared to national trends (expected) and Organs Transplanted per Donor (OTPD)

*Control: October 1st - November 31st (n = 31)

**Sample: December 1st - January 31st (n = 34); SCD: Standard Criteria Donor (age < 60, or between ages 50 – 59 without a history of hypertension, a serum creatinine > 1.5 and death due to stroke or aneurysm); ECD: Extended Criteria Donor (age 60 or over, or between ages 50 – 59 with two or more of the following: hypertension, creatinine > 1.5, or death due to stroke or aneurysm).

Relationship of Results to Objectives

In collaboration with the leadership of DNAZ, a needs assessment questionnaire provided insight into an educational presentation that offered suggestions to overcome the barriers that were in place of implementing recruitment methods as part of their plan. Owing to the needs assessment result indicating that 95% of the transplant clinicians would change their practice if provided with sufficient evidence suggesting that a specific method improved DMGs and LTPD,

it was necessary to perform the educational intervention from the lens of an evidence-based practitioner. Therefore, a section of the presentation focused on the systematicity of models like PICO questions, PDSAs, and literature reviews while the implementation into practice models focused on the grounds of sound models and theoretical roots (Iowa Model of Evidence-Based Practice, 2017) (Appendix E). For example, through raw numbers retrieved from national databases such as the Scientific Registry of Transplant Recipients (2018) (Figure 1), global perspectives were gained, and practical insight into the evidence achieved.

Although statistics were necessary components of the educational intervention, it was mutually essential to identify gaps in the knowledge, skills, and comfort level of each separate alveolar recruitment maneuver in the guidelines. For example, since IRV was the highest ranked for (1) comfort level, (2) safety, and (3) familiarity (Table 2), education regarding those aspects of this mode of ventilation wouldn't likely be to be of much use whereas addressing those with lower rank were necessary. The most concerning assessment finding was that each of the three methods had equal ranking of barriers limiting the ability to perform alveolar recruitment maneuvers, therefore interventions informing how to remove those roadblocks deserved attention and were a significant part of the educational in-service (Appendix E). A participant of the educational intervention suggested an unforeseen resolution to the roadblock; inclusion of an algorithm flowsheet in the organ donor binders as a tool that transplant clinicians could use to hand to respiratory therapists when initiating this protocol was created (Figure 7). As a result, the revised version of the algorithm used for the IRV PDSA will be a component of the upcoming DNAZ CPGs and algorithms were printed and added to donor charts to be used as a reference when making ventilator changes.

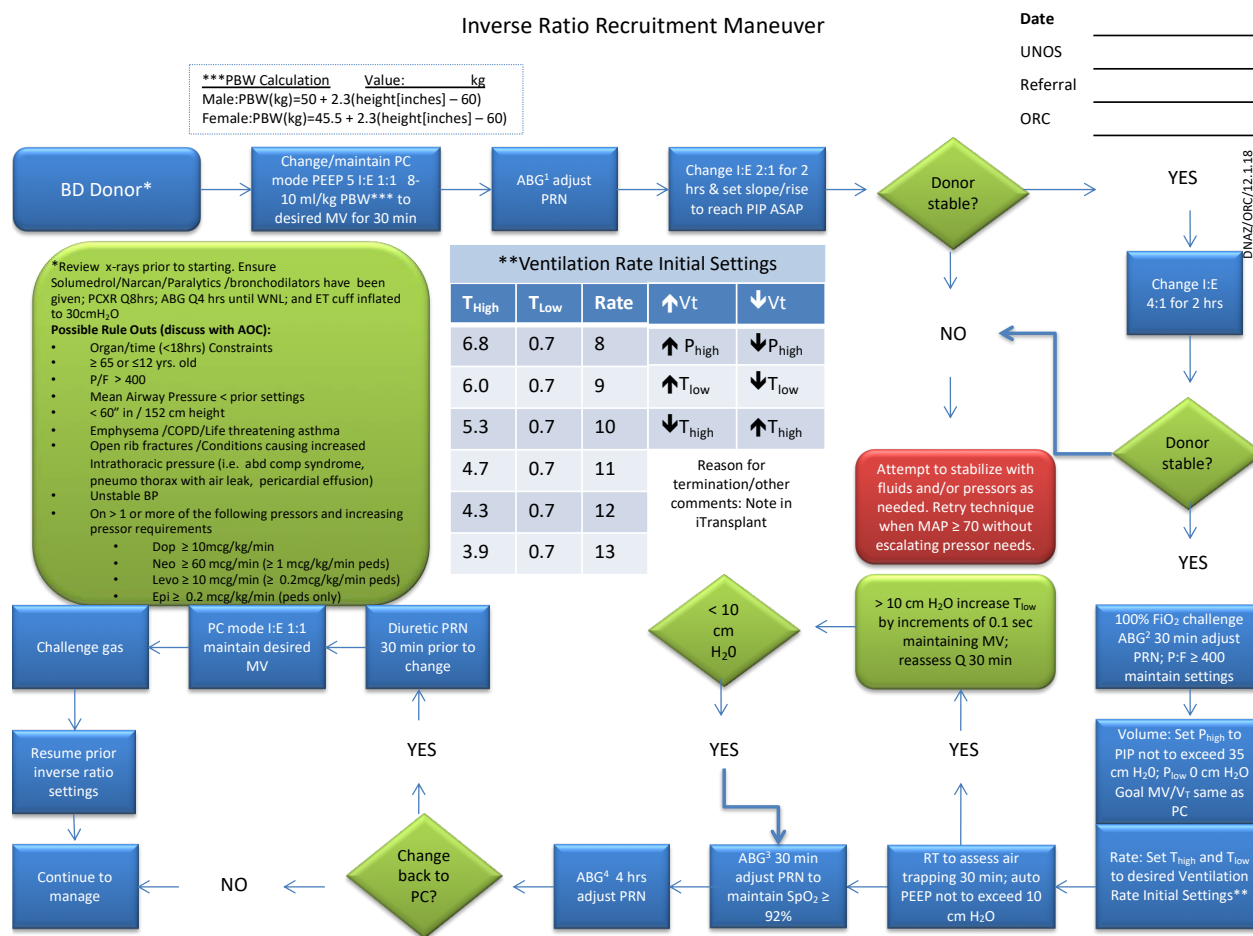


FIGURE 7. Inverse ratio ventilation recruitment algorithm. (Modified from the IRV PDSA (Bergstrom & Bell, n.d.))

Strengths, Limitations and Future Implications

Knowledge is the systematic organization of laws and theories used to describe and predict phenomena whereas EBP is the act of practicing those events (Moran & Burson, 2017). Although EBP mandates a more holistic approach to what is known than a quality improvement model, at DNAZ many of the necessary theoretical underpinnings were successfully translated into practice owed to transplant clinicians commitment to prior PDSAs which paralleled the selected practice model. In this project, the knowledge acquired employing observation and experimentation were applied to the Iowa Model to encourage practitioners to move from their

current practice to one of EBP. The disposition of this type of guided educational intervention helped ameliorate barriers that were in place of performing alveolar recruitment maneuvers and improved donor management in the perioperative period, which was the scholarship of this project. To improve the quantity and quality of return, respondents' anonymity was ensured by a third party (i.e., Qualtrics Experience Management), which likely maintained the integrity of the answers by those who reported their experiences. Although lung donation rates can vary substantially from month-to-month, this EBP in-service focused on improving LTPD, OTPD and closing the gaps between these values and therefore their improvements were likely the results of the intervention. For example, of the 31 donors in the two months prior to the intervention, 26% became lung donors whereas after the intervention the LTPD was 41%. Organs transplanted per donor improved from 3.0 to 4.21 ($p < .01$) and the O: E gap was closed (from -0.95 OTPD to +0.02).

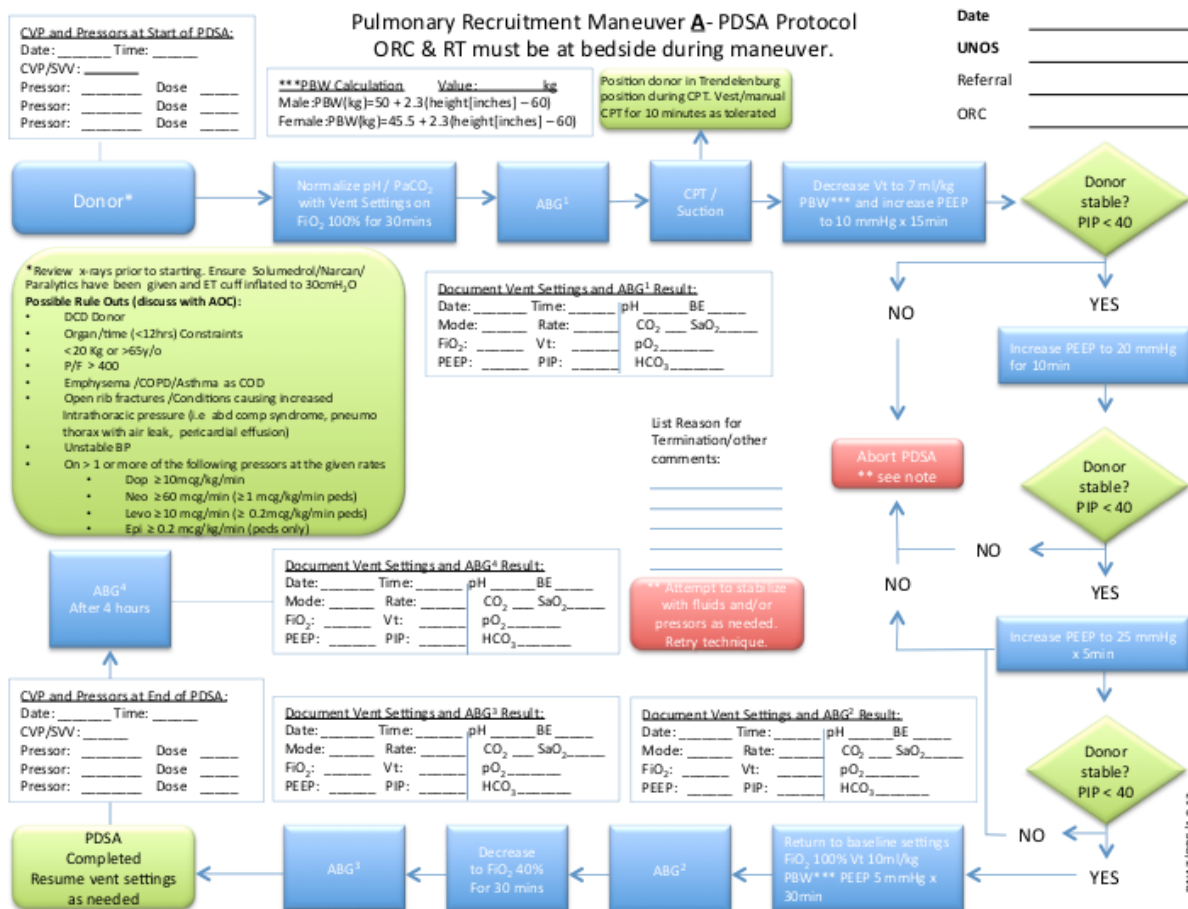
However, there was a shortcoming of this project in that a goal was to increase the ratio of donors meeting seven DMGs (58% pre-intervention vs. 56%) sample. From the data, a combination of improved OTPD with a concurrent decline in the DMGs was not a phenomenon described in the literature (Franklin, Santos, Smith, Galbraith, Harbrecht & Garrison, 2010; Malinoski et al., 2012). This could imply: (1) a potential imbalance in the focus of the educational intervention between methods of meeting DMGs versus OTPD; (2) there may be separate barriers between meeting DMGs and OTPD that were not addressed; or (3) the tools themselves may not be appropriate measuring devices of each other. Additional weaknesses of the project involved the validity in the evaluation form design in its purpose to address the concern. The assessment form informed the building of the in-service but there should have been

a measure to compare the pre and post comfort level, intention to employ CPG, or a knowledge-based question that was directly comparable in a pre and posttest manner. Also, it is unknown which respondents (n=21) of the assessment form completed the in-service and subsequent evaluation form (n=25). Warranted are interventions aimed at improving both DMGs and OTPD merits in addition to evaluating the intervention using a validated pre and posttest tool. It would also be helpful to continue to assess if the newly created algorithm enhances the utilization of the CPGs. Dissemination of this project should serve as not only a guide but as a template for future practices of donor management regimes

APPENDIX A:
DONOR MANAGEMENT GOALS

APPENDIX B:

PULMONARY RECRUITMENT MANEUVER A – PDSA PROTOCOL



APPENDIX C:

PULMONARY RECRUITMENT MANEUVER B – PDSA PROTOCOL

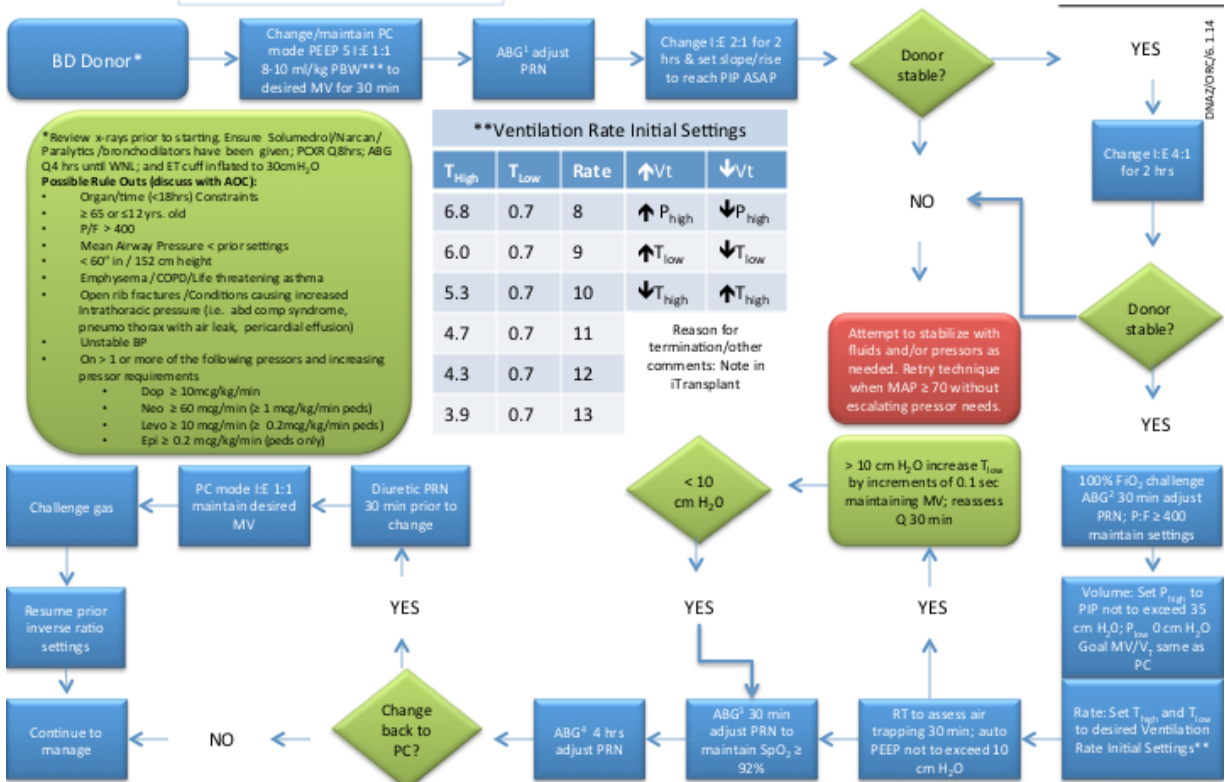
APPENDIX D:

INVERSE RATIO RECRUITMENT MANEUVER – PDSA PROTOCOL

Inverse Ratio Recruitment Maneuver - PDSA Protocol ORC & RT must be at bedside

Date _____
UNOS _____
Referral _____
ORC _____

****PBW Calculation Value: _____ kg**
Male: $PBW(kg) = 50 + 2.3(\text{height[inches]} - 60)$
Female: $PBW(kg) = 45.5 + 2.3(\text{height[inches]} - 60)$



- *Review x-rays prior to starting. Ensure Solumedrol/Narcan/Paralytics/bioinoculators have been given; PDR Q8hrs; ABG Q4 hrs until WNL; and ET cuff inflated to 30cm H₂O**
- Possible Rule Outs (discuss with AOC):**
- Organ/time (<18hrs) Constraints
 - P/F > 400
 - Mean Airway Pressure < prior settings
 - < 60" in / 152 cm height
 - Emphysema / COPD/Life threatening asthma
 - Open rib fractures /Conditions causing increased Intrathoracic pressure (i.e. abd comp syndrome, pneumo thorax with air leak, pericardial effusion)
 - Unstable BP
 - On > 1 or more of the following pressors and increasing pressor requirements
 - Dop ≥ 10mcg/kg/min
 - Neo ≥ 60 mcg/min (≥ 1 mcg/kg/min peds)
 - Levo ≥ 10 mcg/min (≥ 0.2mcg/kg/min peds)
 - Epi ≥ 0.2 mcg/kg/min (peds only)

DONA2/03/06.1.14

APPENDIX E:
EDUCATIONAL INTERVENTION

ALVEOLAR LUNG RECRUITMENT MANEUVER UTILIZATION AMONG TRANSPLANT CLINICIANS IN ARIZONA

- Objectives

1. Discuss the background of local and national needs for transplant.
2. Review brain death and the physiological complications associated.
3. Describe how meeting Donor Management Goals (DMGs) are associated with improved outcomes and methods used to reach those endpoints.
4. Identify gaps in quality of care and practice options to ameliorate those gaps.
5. Explore evidence-based practices – what are other centers doing?
6. Application of theoretical frameworks into executing practice.
7. Conclusion and areas for further research.

- Background

1. As of mid-year, UNOS/OPTN reported nearly 115,000 people needing an organ transplant and of those over 1,500 were awaiting lungs.
2. While the number of overall transplants has increased over the last five years, the national average of lungs transplanted per donor (LTPD) has remained approximately 21%. In Arizona from 1995 to June of 2018, there have been over 80 patients that have died while awaiting lung transplant.

- Brain Death

1. To understand brain death it is first important to review normal anatomy.
2. The anterior and posterior pituitary glands synthesize, store and secrete hormones that act on target organs to create a response.
3. For example – Antidiuretic hormone, which is secreted by the **posterior pituitary gland**, acts on the collection tubule's aquaphores to enhance the reabsorption of water in states of high serum osmolarity. Since water is reabsorbed serum osmolarity decreases and intravascular volume is increased.
4. Adrenocorticotrophic hormone is another example of a neuroendocrine hormone that is secreted by the anterior pituitary gland and acts on the adrenal cortex causing it to

release cortisol hormones – gluco & mineralocorticoids that stimulate release of sympathetic hormones epinephrine, norepinephrine, and aldosterone.

- **Herniation of the Cerebellum**

1. In acute head injuries intracranial compliance is biphasic in that the pressure within the cranial vault is directly related to the volume.
2. As total intracranial volume increases during the process of herniation a pattern known as Cushing's Triad, which is characterized by increased pulse pressure, bradycardia, and irregular respirations occurs because of massive catecholamine release. This sympathetic storm is thought to be a proliferative mechanism of the body's attempt to maintain cerebral perfusion. Unfortunately, this hyper-dynamic process often leads to a stunned myocardium from the increased workload, which commonly leads to respiratory problems such as atelectasis and edema.
3. Then, when the system fails to maintain a life sustainable cerebral perfusion pressure and herniation occurs, hypotension results as the hypothalamic-pituitary axis is abolished, and spinal, cardiogenic, and distributive shock ensues. This post-herniation hypotension phenomenon negatively affects all transplantable organs and often leads to cardiac death.

- **Local Problem and Treatment Goals**

1. But when it doesn't, and organ systems remain perfused and oxygenated by the beating-heart, the damage is addressed during donor management, and while recipients are located to receive their gift.
2. The Donor Management Goals are a set of 9-goals, which are essentially critical care endpoints, that we attempt to achieve in order to demonstrate recovered organ function.
3. Although oxygenation involves all these end-points, ventilator management directly involves two of them, pH and P: F which serves as an indirect indicator of lung function.
4. Why is this important? Using this tool, identifies the end-points that transplant clinicians aim to reach. Research shows that meeting them, or at least 7 of them, is

associated with increased organs transplanted per donor and improved graft function in recipients. What this Tool doesn't tell you is how to reach these goals, which is where clinical practice guidelines, such as the pulmonary plan of care come into place

- Lung Recruitment

1. The pulmonary plan of care for clinically managing the brain dead donor simply involve addressing the common conditions that occur between the incident causing the Brain death, and from the time organs are recovered.
2. Atelectasis – or the collapse of alveoli is the most common reversible lung condition that occurs due to the lack of cerebral diaphragmatic innervation and the necessity for positive pressure ventilation.
3. Infiltrates as a result of pneumonia, which can occur due to aspiration during herniation, during the hospital stay, or because of ventilator acquired pneumonia.
4. Whereas pulmonary edema results from the stunned myocardium, massive proinflammatory interleukin release and aggressive fluid resuscitation.
5. Where the later two are treated with medications and judicious fluid management, atelectasis is the condition in which the scholarship of this proposal's interest.
6. At Donor Network of Arizona the objective of Section III, Article VIII of the CPGs involves applying methods of mechanical recruitment maneuvers that aim to improve atelectatic lung conditions.
7. Generally recruitment maneuvers aim to minimize lung stretch, while applying enough pressure to reverse atelectatic lung conditions related to the Brain death process.

- Local Problem History

1. In 1999, UNOS created the Critical Pathway for the Organ Donor that recommended physiologic goals and an approach to donor management which included specific treatments and monitoring. This document was largely based on opinion grade evidence and hasn't been updated since 2006 and therefore it is largely at the discretion of the OPO to determine how goals for donor management are achieved.

2. Of the nine DMGs, meeting the goal: *partial pressure of arterial oxygen (PaO₂) to fraction of inspired oxygen (FiO₂) P: F ratio* is commonly missed at DNAZ.
 3. The goals from then to now haven't changed [Table 2. Question3], you have you have all said that meeting DMGs and LTPD is an important part if you choose to perform recruitment maneuvers, in 2011, Pulmonary Recruitment Maneuvers were introduced into the DNAZ clinical practice guidelines (CPGs) as a reflection of changing trends in using ventilator techniques for lung donor management.
 4. But these weren't based on evidence so we compared the two by randomizing the two methods in our CPGs and found no differences between the two.
 5. So we tested another theory only this time we used a continuous maneuver.
 6. Two PDSA's later, we have all three in the CPGs and utility of them are inconsistent.
 7. Furthermore, according to the Scientific Registry of Transplant Recipients local lung utilization is also inconsistent as seen here.
 8. As we can see the transplant trends between PDSA's were different between trials but what this chart doesn't tell us is the transplant trends before the trials.
- Purpose
 1. For this project, the purpose is to improve the knowledge, attitudes, and utilization of Donor Network of AZ's guidelines used to manage donor lungs and therefore presumably increase the number of DMGs met and organs transplanted per donor.
 2. When conducting an experiment or testing a hypothesis scientist often use what is known as a PICO question to help them and their readers succinctly identify the aims of their inquiry.
 3. Which stands for Population – which is the test group, Intervention – what is being done differently in the test group, Control – what you are comparing it against, in other words those that have not had the intervention, and Observation – what are the outcomes?
 4. Which brings us to the survey you took last month (See Figure 6.). The purpose of that survey was an assessment of experiences and presumptions of clinical transplant providers in applying the DNAZ recruitment measures. By the insight yielded from

this survey this educational presentation was created to offer suggestions to overcome the barriers that are in place of implementing recruitment methods as part of your plan.

- Gap in Quality of Care

1. The problem focus trigger or reason for this intervention as it relates to lung donor management at DNAZ involves the shortcoming of meeting the benchmark of the DMGs; at the end of the second quarter of 2018, the expected DMG's met versus actual had a gap of 1.48.
2. To understand the etiology of this gap, your perceptions of the three lung management regimes in the organizations CPGs were first assessed by this questionnaire (See Figure 6.).
3. General categories were ranked between the three guidelines, such as
4. Comfort level - which as we see here we are more comfortable with...
5. Safety - which is surprising due to the complexity and the controversy of this maneuver.
6. Efficacy - which is not surprising considering most of you have all been witnesses the the effects of APRV, and notice the landslide ranking.
7. And finally barriers or limitations to application in the clinical setting - which is problematic considering you all identified IRV as the most comfortable, safest, and most efficient method of recruitment.

- What Else did we Find

1. A review of the maneuvers in the CPG's are needed to improve comfort levels.
2. Which goes hand-in-hand with the need of an educational intervention intervention to inform the physiology of the recruitment maneuvers in our CPGS which we will address in future slides.
3. But for now, to address your responses for this question – if provided with evidence suggesting that a practice improves DMGs and LTPD you would change your practice.

4. We are going to fix this statistic – I routinely perform lung recruitment maneuvers according to the CPGs - by discussing the literature.

- Synthesis of Evidence

1. And by doing so a literature review was performed with the purpose statement to inform the following PICOT question: in brain dead organ donors who have received mechanical lung recruitment maneuvers (P) is there evidence to support which method (I) is superior in improving lung function (C) as demonstrated by improved lung transplantation rates (O) in the perioperative period (T)?
2. An exploration of the recent literature encompassing preoperative management techniques was initiated by using the COCHRANE, PubMed, and CINAHL databases. Of the 270 articles explored, 3-Meta-analyses demonstrated a wide variability in techniques and failed to supply recommendations of specific mechanical ventilatory techniques due to the lack of published high quality and grade clinical trials.
3. The problem is, at the time if these publications there was only one RCT on lung recruitment that compared ARDSnet to non-treatment group. Since then DNAZ has conducted two trials, one of which was a RCT.
4. Otherwise there were 11- research designs that were specific to non-pharmacological, brain dead donor recruitment maneuvers. There have been multiple interventional studies demonstrating improved transplant rates using both recruitment methods (e.g. Continuous versus non continuous) but there lacks high-grade evidence to make NCG recommendations for any specific method. However all sources indicate that recruitment maneuvers are likely an effective treatment method to improve P:F.

- Ventilatory Goals

1. The two methods and three RMs in the current 2015 version of DNAZ clinical practice guidelines reflect a clinical trial that compared two non-continuous recruitment maneuvers.

2. Recently published, the data from this performance improvement initiative whose aim was to seek if either method resulted in improved lung utilization rates showed no difference, then a performance improvement project of continuous donors using inverse ratio ventilation with the primary goals to increase lungs transplanted per donor was performed Using a collaborative approach, similar to the Iowa Model of Evidence Based Practice: we collaborated with St. Joseph's Hospital and Medical center to develop the following algorithm (See Appendix A, B, and C).
 3. Lies in A/a gradients and V/Q matching; A – Alveolar ; a – arterial (think PaO₂) said another way, V – Ventilation = Alveolar ; Q – Perfusion = arterial.
 4. The following video Adopted from Albert et al. in 2009 show EX-vivo lungs of rats with mean airway pressure increases from 20, to 30, to 40 mmHg similar to the Step-Up Peak maneuver shown here (See Appendix B).
- P:F Ratio Comparison
 1. Although research indicates lungs with lower P: F can be safely transplanted, it is generally assumed that a P: F < 300 precludes transplant P: F values demonstrated a significant cubic effect with values increasing at 30 minutes, decreasing at 1 hour and increasing again at 4 hours (p<.01), but were not significantly different by cohort at any of the four time points.
 2. Post-hoc analyses revealed the average P: F at 30 minutes was significantly higher than all other time points and all other comparisons of P: F between time points were not significant.
 3. In our clinical trial we found an overall lung utilization rate of 48% per donor
 4. When the sample is combined with the population of donors during the time period, 20.5% lungs were transplanted per donor.
 5. And the P: F ratio of the donor management goals which were described earlier as being met if > 300, was the most commonly missed DMG.
 - Stage II
 1. Since there really were no differences between the two it was time to come up with a new method.

2. With the hypothesis and destination to find the best way.
 3. Again working with Dignity Health and using similar coordinators, rule out criteria, cohort size and algorithms we trialed our first continuous recruitment maneuver – Inverse ratio ventilation.
 4. And we found similar starting points in terms of initial P: F and confounding variables – and also longevity of the of the improvements as seen here.
 5. The bottom line comparison between maneuvers was clear.
 6. Which should change this statistic – in terms of efficacy there are differences between maneuvers.
- Comparison Between Studies
 1. So how do our results compare to those in the literature? If you can recall from the earlier slide, the only other RCT other than ours showed.
 2. An improvement of lungs “harvested” from 27% in the conventional strategy, which was not identified by the authors to 54% with a cohort of 59 patients (ours 40).
 3. But we haven’t trialed this continuous recruitment method – yet.
 4. What we have trialed, and based our second phase PDSA on is this trial done in 2011 by Hanna an colleagues - which has shown the greatest improvement of lung function between all the published studies in the literature, hence our interest.
 - Theoretical Framework
 1. But just because literature is out – doesn’t mean you will follow it which is where theory is applied. The following diagram is a roadmap of the DNP project you have witnessed and for the sake of time, we will not go through each of these steps, but it is important for you to know this presentation has been based on two theoretical models that aim to fix this statistic – I routinely perform lung recruitment maneuvers.
 2. First, the Iowa model is used to implement evidence into practice. By applying theoretical frameworks that improve staff performance tools such as CPGs are commonly allocated. The varying degrees of adherence to those guidelines depend on many factors such as applicability and demonstrated success. By using an approach to

adopt tools that explore perceptions and experiences. Application of the Iowa model has been applied to those assessments thereby aligning with our institutional goals.

3. However having many positive tributes, the Iowa Model lacks details needed to guide the assessment and evaluation of this project in which Everett Rogers' Theory of Diffusion (2003) will be used to describe the gains of this education intervention. Through the lens of Everett Rogers' *empirical knowledge* an organization of laws and theories will be used for the purpose of describing and predicting phenomena whereas Iowa's Model of EBP will be the act of practicing that phenomena.

- Methods

1. To recap - based on the needs assessment questionnaire we identified a knowledge deficit in that DMG's were not being met.
2. Then, this education intervention which has conducted in accordance with the ABTC criteria for awarding a CEPTCs and based on Roger's theory which was used to provide the foundation that informs an effective solution whereas the Iowa Model used that information to hopefully encourage you to move from your current practice to EBP. The evaluation that will be taken after this presentation will be used to inform my effectiveness.
3. Then, over the next two-months following the intervention, sustainability and efficacy of the education session will be assessed by a retrospective chart review of DMGs met versus missed.

- Conclusion

1. You know what works – you have tested it – Rigorously
2. The way you have tested it is supported by theory and science but most importantly – experience
3. There is one caveat – APRV vs ARDSnet – Anybody for a PDSA?

- Questions

APPENDIX F:
THE UNIVERSITY OF ARIZONA INSTITUTIONAL REVIEW BOARD DETERMINATION
LETTER



Human Subjects
Protection Program

1618 E. Helen St.
P.O.Box 245137
Tucson, AZ 85724-5137
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<http://rgw.arizona.edu/compliance/home>

Date: October 09, 2018
Principal Investigator: Benjamin Scott Bergstrom

Protocol Number: 1810006239
Protocol Title: ALVEOLAR LUNG RECRUITMENT MANEUVER UTILIZATION
 AMONG TRANSPLANT CLINICIANS IN ARIZONA

Determination: Human Subjects Review not Required

Documents Reviewed Concurrently:

Data Collection Tools: *DNP Presentation 10_3.pptx*

Data Collection Tools: *Evaluation Form.docx*

Data Collection Tools: *Needs Assessment Form.docx*

HSPP Forms/Correspondence: *Advisor Confirmation Email.pdf*

HSPP Forms/Correspondence: *Determination of Human Research Bergstrom Revision II.PDF*

Informed Consent/PHI Forms: *Disclosure template-Determination for Research Bergstrom.doc*

Other Approvals and Authorizations: *DNAZ approval copy.pdf*

Regulatory Determinations/Comments:

- Not Research as defined by 45 CFR 46.102(l): As presented, the activities described above do not meet the definition of research cited in the regulations issued by U.S. Department of Health and Human Services which state that "Research means a systematic investigation, including research development, testing, and evaluation, designed to develop or contribute to generalizable knowledge. Activities that meet this definition constitute research for purposes of this policy, whether or not they are conducted or supported under a program that is considered research for other purposes. For example, some demonstration and service programs may include research activities. For purposes of this part, the following activities are deemed not to be research."

The project listed above does not require oversight by the University of Arizona.

If the nature of the project changes, submit a new determination form to the Human Subjects Protection Program (HSPP) for reassessment. Changes include addition of research with children, specimen collection, participant observation, prospective collection of data when the study was previously retrospective in nature, and broadening the scope or nature of the study activity. Please contact the HSPP to consult on whether the proposed changes need further review.

The University of Arizona maintains a Federalwide Assurance with the Office for Human Research Protections (FWA #00004218).

APPENDIX G:
EXECUTIVE SUMMARY

Lung Recruitment Maneuver Practice Guidelines of Organ Donors in Arizona

Benjamin S. Bergstrom

Hello colleagues, as many of you are aware I am completing a Doctorate of Nurse Practice degree which entails a clinical project that demonstrates an intimate knowledge of evidence-based practices. The purpose of this project is to improve the knowledge, attitudes, and utilization of the guidelines used to manage lungs of the donor patient. By completing this Needs Assessment questionnaire, your insight will guide an education presentation that will offer suggestions to overcome the barriers that are in place of implementing recruitment methods as part of your plan.

If you choose to participate in this project, you will be asked to fill out a confidential questionnaire that will take approximately 10-minutes to complete. There are no foreseeable risks associated with participating in this project and you will receive no immediate benefit from your participation. Survey responses are anonymous.

If you choose to participate in the project, participation is voluntary, refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may withdraw at any time from the project. In addition, you may skip any question that you choose not to answer. By participating, you do not give up any personal legal rights you may have as a participant in this project.

Please click the below link to begin your questionnaire:
EXAMPLE: NeedsAssessmentQuestions@qualtrics.org

For questions, concerns, or complaints about the project, you may call Benjamin Bergstrom, S-DNP, CPTC, CCRN at (480)369-1976 or by email at: bbergstrom@email.arizona.edu

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