ABSTRACT

Background: Previous studies have established that end tidal carbon dioxide ($ETCO_2$) can positively predict a return of spontaneous circulation (ROSC) and survivability in out-of-hospital cardiac arrest (OHCA).

Objective: To assess if $ETCO_2$ predicts neurological outcome as measured by cerebral performance category (CPC) score in an independent cohort of patients suffering OHCA.

Methods: This was a retrospective chart review conducted at MedStar Mobile Healthcare of patients who suffered non-traumatic OHCA between January 2014 and July 2014. $ETCO_2$ values were continuously recorded while standard advanced cardiac life support (ACLS) protocols were followed.

Results: OHCA was confirmed in 689 patients. ACLS was initiated in 421 patients. Of those, 214 patients were transported to the hospital. There was a good neurologic outcome (CPC 1or 2) in 22 patients and a poor neurologic outcome (CPC of 3, 4, or 5) in 183 patients. Initial $ETCO_2$ ($p=0.027$, OR 1.002, 95% CI 1.000-1.003) and $ETCO_2$ after ROSC ($p=0.007$, OR 0.997, 95% CI 0.995-0.999) were correlated to neurological outcome when using binary logistic regression.

Conclusion: Initial $ETCO_2$ and $ETCO_2$ after ROSC are predictors of neurological outcome in OHCA. After further research this data can be incorporated into criteria on whether to perform cardiopulmonary resuscitation on patients suffering OHCA.

CORRELATION OF END-TIDAL CARBON DIOXIDE TO NEUROLOGICAL OUTCOME IN OUT-OF-HOSPITAL CARDIAC ARREST

INTERNSHIP PRACTICUM REPORT

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By

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION:

This practicum report summarizes the internship at MedStar Mobile Healthcare by Sabrina Phillips. During the time there involvement included multiple research studies through various entities that involved predominately cardiac arrest in a pre-hospital setting. The primary responsibility was undertaking a research study about the correlation of end-tidal carbon dioxide to neurological outcome in out-of-hospital cardiac arrest.

Each year in the United States over 400,000 people suffer out-of-hospital cardiac arrest (OHCA) with an overall survival rate of approximately 5% [1]. With such low survivability and high cost of care for those that undergo a cardiac arrest there is a need to decipher when efforts to resuscitate in the field should be considered futile. End tidal carbon dioxide ($ETCO_2$) has been well documented to positively correlate with the survivability of a cardiac arrest [6-9], and has successfully been demonstrated as a parameter to predict the occurrence of return of spontaneous circulation (ROSC) in multiple studies [6-8, 10-12, 14]. To date, however, data on whether $ETCO_2$ correlates with the neurological outcome of a victim of OHCA are lacking. This practicum report is a pilot study on the clinical correlation of $ETCO_2$ in OHCA with neurological outcome.

This is an observational study in which data was collected retrospectively for victims of cardiac arrest attended by MedStar personnel. As such, the study presented little risk of potential harm to study subjects. This study protocol was approved by the University of Texas Southwestern IRB (protocol number STU 052011-134) and reciprocity was granted by the University of North Texas Health Science Center IRB (2014-123).

Collection of data occurred through an electronic database of patient records called Siren. This database allows a specific search to be performed for the exact criteria needed; therefore no patient records unassociated with the study were observed. The electronic patient care record along with the associated electrocardiogram (EKG) file was reviewed for necessary data. The neurological outcome in the form of cerebral performance category (CPC) was collected from the hospital to which the patient was transported. SPSS Software was used to test for correlation between CPC and $ETCO_2$.

The final chapter of this report discusses the experience at MedStar Mobile Healthcare. There is detail about the projects enlisted to assist on and how they enlightened further personal research. The report concludes with a summary of the daily journal kept while at the establishment.

II. INTERSHIP SUBJECT: End-tidal carbon dioxide – The next piece in cardiac arrest algorithms.

A. Background and Literature:

Each year in the United States over 400,000 people suffer OHCA with an overall survival rate of approximately 5% [1]. The poor outcomes are driving the reassessment of current EMS treatment protocols. One of the biggest challenges in EMS is to improve results of cardiopulmonary resuscitation (CPR) and the subsequent quality of life after a cardiac arrest.

Cardiac arrest is the cessation of electrical activity within the heart to adequately initiate the rhythmic beating of the heart to supply blood and nutrients to the body. CPR is the process of treating the heart in a necessary manner to re-establish the correct electrical activity in order to perfuse the body. Treatment modalities differ based on the underlying cause of the cardiac arrest. Current treatments can include electrical therapy, cardiac medications and/or surgery.

The body produces carbon dioxide (CO_2) as a byproduct in cellular respiration. The CO_2 then diffuses from the cells into the plasma. The molecule is transported as dissolved CO_2, combined with hemoglobin, or most predominately, as bicarbonate. CO_2 is then off loaded at the alveoli to be exhaled by the lungs. In cardiac arrest the carbon dioxide begins to accumulate within the cells due to lack of perfusion.

Studies have shown that there is a close correlation between cardiac output, stroke volume, coronary perfusion pressure and $ETCO_2$ [15-17]. Capnometry is the measurement and numerical display of the $ETCO_2$, which is the concentration of CO_2 expired in a respiratory cycle. A capnogram is a graphical representation in waveform format of the partial pressure of expired CO_2. Capnometry for use in cardiopulmonary resuscitation was first described by Kalenda in 1978 [18]. $ETCO_2$ was used to monitor effectiveness of CPR. A decrease in $ETCO_2$ indicated that the person performing chest compressions was possibly tiring and executing inadequately, indicating that a transfer to other personnel needed to be made. This study was also first to show a decrease in $ETCO_2$ in patients who were not resuscitated and a significant increase in $ETCO_2$ in patients who achieved ROSC [18].

Current guidelines promulgated by the American Heart Association indicate that an abrupt, sustained increase in $ETCO_2$ during CPR is indicative of ROSC [1]. Pokorna et al recorded $ETCO_2$ levels around the time at which ROSC was achieved and found that constantly ventilated patients undergoing ALS had an $ETCO_2$ of approximately 10 mmHg higher after ROSC was achieved than before [10]. Studies such as this have allowed incorporation of $ETCO_2$ in the field treatment of OHCA.

Several other studies also indicated $ETCO_2$ as a predictor of ROSC and survivability after a cardiac arrest [6-12, 14-16]. Kolar and colleagues in a study of 1087 non-traumatic adult cardiac arrest cases saw that there was no survivability with an $ETCO_2$ of 14.3 mmHg or less after 20 minutes of CPR [8]. The sensitivity, specificity, positive predictive value and negative predictive value were all 100%, proving $ETCO_2$ as a predictor of ROSC. Wayne, Levine and Miller in a three year study including 90 non-traumatic adult cardiac arrest patients that presented in pulseless electrical activity (PEA) noted that if after 20 minutes of CPR a patient had an $ETCO_2$ of 10 mmHg or less it indicated death [9]. The authors suggested that $ETCO_2$ could be used to prevent unnecessary hospital transports of cardiac arrest patients. However, Callaham and Barton found in their study that four out of their 55 cardiac arrest patients who had an initial $ETCO_2$ of less than 10 mmHg were resuscitated [19]. Similarly, Rognas and colleagues in a 2011 study found 4 out of 271 cardiac arrest patients that had an initial $ETCO_2$ of 10 mmHg or less that were resuscitated [20]. Studies such as these [19, 20], showing that $ETCO_2$ does not predict ROSC may account for the reluctance of the medical community to incorporate $ETCO_2$ into resuscitation algorithms and standardized analysis reports. The contradictory studies, however, fail to account for prior studies suggesting initial $ETCO_2$ to be non-predictive. Current research claims that only the $ETCO_2$ obtained at later times in a cardiac arrest, most predominately after 20 minutes of CPR, as an accurate predictor for ROSC and survivability.

MedStar, a world leading mobile healthcare provider, is the 911 emergency response system for the majority of Tarrant County. MedStar provides care to the population they serve in a variety of ways; they are not simply a 911 emergency response company. The newest leading development within the company has been the creation of the Community Health Paramedic position. This position allows for a paramedic to provide in home care for patients with chronic illnesses that need assistance in long-term management of their diseases. By doing this, the patient is able to decrease the amount of time spent at physician offices and hospitals. MedStar responds to a large call volume for a variety of emergencies on a daily basis. On average, paramedics within the system treat approximately 100 cardiac arrests each month

MedStar protocols for responses to OHCA are as follows. In the MedStar system an ambulance is staffed with both an emergency medical technician (EMT) and a paramedic or with two paramedics. All are certified to care for patients at their certification level within the state of Texas. Furthermore, they are credentialed within the MedStar system to care for patients as specifically directed by MedStar protocols. The mobile intensive care unit (MICU) is staffed and stocked with appropriate tools to provide advanced life support (ALS). [25]

Once the 911 system has been activated by a caller, the call is directed to the communications center. A call taker relays the information received from the caller to the responders dispatched via radio and computer. The call taker will also ask the caller to begin chest compressions while awaiting the arrival of responding units. Ambulances are assigned to a specific destination to await a call, at locations dictated by need prediction software used in dispatch. The closest MICU is dispatched to the incoming call of highest priority. A cardiac arrest is dispatched as a priority one if it is considered acute. If a patient is noted to have obvious signs of death the call is then dispatched as a priority three. In a priority one, if available a supervisor or critical care paramedic (CCP) is also dispatched to assist the responding unit and provide an increased level of care. Due to limited availability, supervisors and critical care paramedics are not present at every cardiac arrest. [25]

Once on scene, the crew confirms the patient is in cardiac arrest and then begins CPR unless obvious signs of death (decapitation, incineration, dependent lividity, rigor mortis, decomposition, cardiac arrest caused by blunt force trauma) are present [5]. The patient is continuously monitored using a Philips HeartStart MRx monitor/defibrillator (Philips Medical Systems, Andover, MA, USA). A Q-CPR Measurement and Feedback tool (Philips Medical Systems and Laerdal, Andover, MA, USA) is applied to the patient's chest to monitor correct compression depth, recoil and rate. The device verbally and visually cues the crew when adjustments need to be made to supply adequate compressions. Advanced cardiac life support (ACLS) is provided as dictated by standing MedStar protocols [5]. If a supervisor or CCP is on scene the LUCAS 2 Chest Compression System (Physio-Control, Redmond, WA, USA) device is deployed to provide automatic compressions. The patient is intubated with a King LTS-D disposable supraglottic airway with gastric access (King Systems, Noblesville, IN, USA) with a capnometer attached between the airway and a standard adult bag-valve device and plugged into the monitor. CO_2 is measured continuously with a Microstream (sidestream) method by an infrared capnometer integrated into the Philips defibrillator/monitor. The Microstream method has a hydrophobic filter inside the FilterLine to avoid condensation that would alter the reading [21]. To derive the partial pressure of the CO_2 the concentration of the carbon dioxide is multiplied by the ambient pressure. The PCO_2 is then used to derive the $ETCO_2$ measurement. Data is displayed as both an $ETCO_2$ digital report and a CO_2 waveform. The patient is ventilated at one breath every fifteen seconds with 100% oxygen being delivered at 15 liters per minute while no pulse is present. If the patient regains a pulse ventilations transition to one breath every five seconds. [5]

Standing orders dictate that the patient receives a minimum of thirty minutes of full ACLS care; if ROSC is not obtained after thirty minutes, efforts are terminated and time of death noted [5]. If the patient has a ROSC they are stabilized and then transported to the closest appropriate hospital. An exception to this protocol is if the arrest occurs in a public location or the family is uncomfortable with field termination, the patient would then be transported to the closest appropriate hospital whether they have a pulse or not. At emergency department arrival patient care is transitioned to hospital staff.

This study uses data collected by MedStar personnel on cardiac arrest patients to examine $ETCO_2$ in correlation to the neurological outcome. The data was also secondarily used to account for other predictors of outcome in cardiac arrest including age, sex, weight, comorbidities, race, duration of arrest, initial monitored heart rhythm, if the arrest was witnessed, and if bystander CPR was performed.

Prior studies have shown how $ETCO_2$ can be used as indicators for CPR proficiency, if a ROSC will be obtained, and even survivability. The next step is to know if the patient will not just survive, but what will their quality of life be if they do.

B. Aims:

The aim of this practicum was to assess if $ETCO_2$ predicts neurological outcome as measured by CPC score in an independent cohort of patients suffering OHCA. If this is true, $ETCO_2$ will be positively correlated with CPC score.

C. Significance:

Because OHCA is so common, there is a need to assess how to improve not only survivability but also quality of life after the event. The current general rule for termination of resuscitation (TOR) in OHCA [13] is very broad and leads to many patients being transported to a hospital but not surviving. Because patient transport uses essential resources, it is worthwhile to determine when transport is most likely to improve patient outcomes, thereby improving protocols for field efforts at resuscitation. Particular attention to when resuscitation efforts should be considered futile and ceased is necessary. This change would save money and resources from being used on victims that would not have a positive outcome despite any amount of treatment they receive and allow those resources to be diverted to other cases. $ETCO_2$ has been shown to be a positive predictor of ROSC and survivability [6-12, 14] but its correlation to neurological outcomes is not yet known. I therefore analyzed the possible correlation between $ETCO_2$ and CPC in patients who survive OHCA in order to assess not only survivorship but also quality of life outcomes for OHCA patients.

D. Materials and Methods:

1. Data

This was a retrospective study where patient data were collected from an electronic database of patient charts in a pre-hospital setting for analysis to test for a correlation between $ETCO_2$ and neurological outcome (CPC score, see below) in OHCA. This study protocol was approved by the University of Texas Southwestern IRB (protocol number STU 052011-134) and reciprocity was granted by the University of North Texas Health Science Center IRB (protocol number 2014-123).

The effects of several other variables was tested using logistic regression. The data reviewed include: whether or not the patient was dead on arrival, whether the patient was transported or not (resuscitation efforts were terminated in the field), time of ROSC, initial $ETCO_2$, $ETCO_2$ at 5, 10, 15, 20 and 25 minutes (unless ROSC achieved earlier), $ETCO_2$ after ROSC, $ETCO_2$ at Emergency Department (ED) arrival, lowest and highest $ETCO_2$, and the dependent variable of interest, CPC score. I defined ROSC in accordance with the Utstein-style, meaning a palpable pulse at the carotid artery regardless of duration [22].

The following variables were tested to assess if their inclusion would improve the model: age, sex, weight, and race. Comorbidities (including cancer, diabetes, heart disease, renal disease, respiratory disease, and stroke), the initial heart rhythm, duration of arrest, if the arrest was witnessed, if bystander CPR was performed and the duration of arrest prior to EMS arrival were also assessed as potential predictors of neurologic outcome.

A CPC category is assigned as follows: 1-good cerebral performance, 2-moderate cerebral disability, 3-severe cerebral disability, 4-coma or vegetative state, and 5-brain death [23]. Detailed definitions of each CPC score can be seen in the table below. A score of 1 or 2 is considered a good outcome and 3-5 are considered poor outcomes in this study.

Table 1 – Cerebral Performance Categories

1	Good cerebral performance	conscious, alert, able to work, might have mild neurologic or psychologic deficit
2	Moderate cerebral disability	conscious, sufficient cerebral function for independent activities of daily life, able to work in a sheltered environment
3	Severe cerebral disability	conscious, dependent on others for daily support because of impaired brain function, ranges from ambulatory state to severe dementia or paralysis
4	Coma or vegetative state	any degree of coma without the presence of all brain death criteria, unawareness, if appears awake then no interaction with environment, may have spontaneous eye opening and sleep/wake cycles, cerebral unresponsiveness
5	Brain death	apnea, areflexia, EEG silence

2. Collection Methods

To collect the data, electronic medical records and electrocardiogram (EKG) files created by field paramedics on Siren3 ePCR Suite (Medusa Medical Technologies Inc., Halifax, Nova Scotia, Canada) were used. Siren is the current charting software used within the MedStar system to create patient care records. Once a paramedic finalizes the patient record at the completion of care the chart is saved into an electronic records database. This database holds all patient encounters within the MedStar system. The database is used for systemic performance audits, billing, patient care records, and allows secure storage of all protected health information.

The information for this study was obtained by performing a search through the Siren database. The search criteria included incident date and a chief complaint of cardiac arrest or respiratory arrest. All files meeting these measures were downloaded and reviewed. If not already uploaded to Siren, the EKG files were retrieved individually from the monitor used during the cardiac arrest and uploaded to the MedStar database. Pertinent data was then input into an Excel spreadsheet for statistical analysis in Excel, SPSS, and R (see below), at which point in time data were anonymized and disassociated from identifiable information such as patient name or date of birth.

3. Population

The study community includes 880,000 inhabitants of fifteen cities serviced by MedStar Mobile Healthcare. The MICU posting and dispatch policies (see Background) allow the population to be completely randomized for all variables. All non-traumatic, normothermic out-of-hospital cardiac arrests in adults 18 years and older from January 2014 to July 2014 were included in the study. Exclusion criteria were traumatic arrest, severe hypothermia (<30 degrees

Celcius), younger than 18 years, and ROSC before intubation. The latter exclusion is due to the fact that no $ETCO_2$ can be collected in these cases.

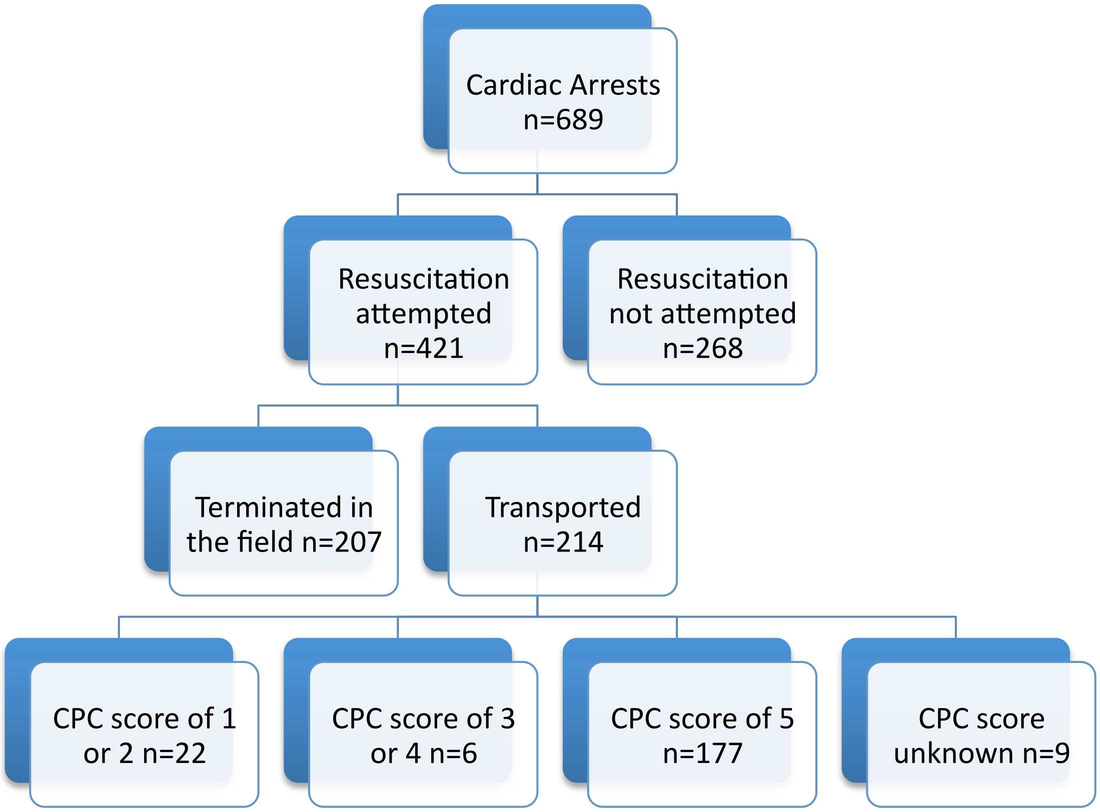
The average age of the patients was (63±16 years); 40% of the patients were female and 60% were male (Table 2). The racial division was 60% White, 26% African American, 13% Hispanic, 2% Asian, and <1% Indian (Table 2). There were 689 confirmed cases of cardiac arrest. Resuscitation was not attempted in 268. Of the 421 patients who had resuscitation attempted, 207 patients were pronounced dead in the field after 30 minutes of attempted resuscitation, and the other 214 patients were transported to the hospital. The patients that were transported had final CPC scores as follows: 22 patients with a 1 or 2, 6 with a 3 or 4,177 with a 5, and 9 missing. (Figure 1)

Table 2 – Descriptive statistics of subject population

Age (mean±SD)	Sex	Race
•63±16 years	•Female n=275	•White n=396
	•Male n=414	•AA n=171
		•Hispanic n=84
		•Asian n=10
		•Indian n=2

Key: n=number of patients, AA=African American

Figure 1 – Utstein reporting template for OHCA



Key: n=number of patients, CPC=Cerebral Performance Category

4. Analysis

The relationship between $ETCO_2$ and CPC was determined using logistic regression. Other variables assessed to be included in the model are listed in the Methods section, so that the equation that was evaluated is:

CPC Score = (constant) + x1(initial $ETCO_2$) + x2(age) + x3(sex) + x4(weight) + x5(race) + x6(history of cancer) + x7(history of diabetes) + x8(history of heart disease) + x9(history of renal disease) + x10(history respiratory disease) + x11(history of stroke) + x12(initial heart rhythm) + x13(duration of arrest) + x14(if arrest was witnessed) + x15(bystander CPR performed) +

x16(duration of arrest prior to EMS arrival) + x17(if patient was transported) + x18($ETCO_2$ at 5 minutes) + x19($ETCO_2$ at 10 minutes) + x20($ETCO_2$ at 15 minutes) + x21($ETCO_2$ at 20 minutes) + x22($ETCO_2$ at 25 minutes) + x23($ETCO_2$ at ROSC) + x24($ETCO_2$ at ED arrival) + x25(highest $ETCO_2$) + x26(lowest $ETCO_2$)

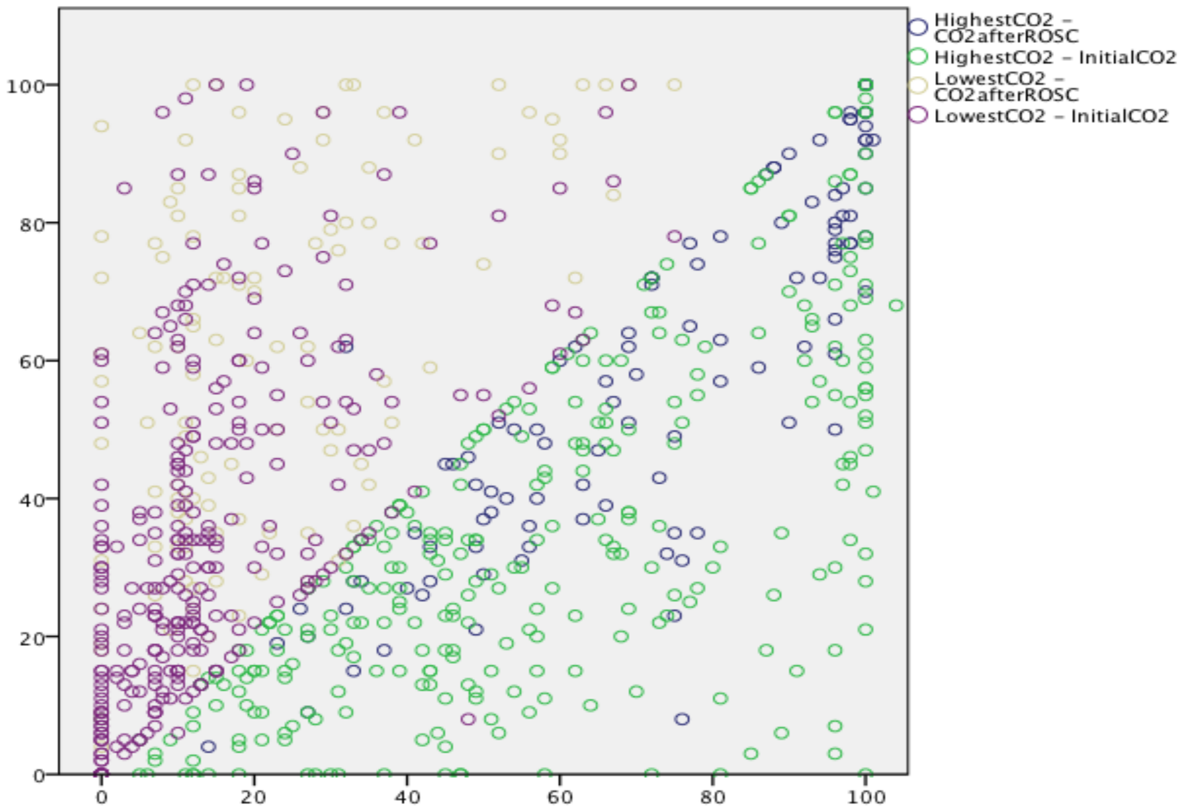
Because of the large number of variables (26 total variable) included in the model, I used a power analysis to determine the sample size required for the regression model to be statistically valid. To predict the sample size needed to yield statistically cocclusive data an A-priori Sample Size Calculator for Multiple Regression (Version 3) software was used [24]. A minimum sample size of 175 was calculated with anticipated medium effect size of 0.15, a power level of 0.8, an alpha of 0.05, and 26 predictors. The actual sample size obtained for this study was 308 patients. Summary statistics are presented as means with a standard deviation. Logistic regression was done using SPSS (Version 21) software (SPSS Inc., Chicago, IL, USA). Analysis for independent predictors of neurological outcome from univariate analysis was performed using binary logistic regression, including tests for covarying predictors.

E. Results

Each variable in the proposed model for the logistic regression (listed above) was tested for significance, goodness of fit and covariance. The only variables that showed significance were initial $ETCO_2$, $ETCO_2$ after ROSC, highest $ETCO_2$, and lowest $ETCO_2$. These were tested for covariance with a scatter plot matrix that showed a relationship between $ETCO_2$ after ROSC and highest $ETCO_2$ (Figure 2).

Figure 2 – Scatter plot matrix of significant variables to evaluate covariance.

Highest $ETCO_2$ and $ETCO_2$ after ROSC.



x and y axis show $ETCO_2$ in mmHg

As a result the highest $ETCO_2$ was removed. The logistic regression was run again with just initial $ETCO_2$, $ETCO_2$ after ROSC and lowest $ETCO_2$. This equation showed that the variable lowest $ETCO_2$ was not significant; thus, the lowest $ETCO_2$ value was removed from the model. The final best-fit model is

CPC = -2.286 + 0.002(Initial $ETCO_2$) – 0.003($ETCO_2$ after ROSC)

This equation is proven as the best model through the logistic regression performed showing significance for initial $ETCO_2$ (34±25)(p=0.027, OR 1.002, 95% CI 1.000-1.003) and $ETCO_2$ after ROSC (60±26)(p=0.007, OR 0.997, 95% CI 0.995-0.999). (Table 2) Since there was a large sample size, the Hosmer and Lemeshow test was used to show a goodness of fit for the model. There was significance seen in both the included variables showing that they are in fact correlated to the CPC score. The model showed a high significance for the goodness of fit test ($p=0.841$), which rejects that the variables were not a good fit and therefore proving that the model is correct.

Table 3 – Variables associated with CPC score in OHCA

Variables	Odds Ratio	95% CI	p-Value
Initial $ETCO_2$	1.002	1.000-1.003	0.027
$ETCO_2$ after ROSC	0.997	0.995-0.999	0.007

Key: $ETCO_2$ = end-tidal carbon dioxide, ROSC = return of spontaneous circulation, CI = confidence interval

F. Discussion

Initial thoughts lead to the expectance that there would be multiple predictors and covariance that would need to be accounted for within the model to make it significant. This expectation was based on biological predispositions of certain aspects being predictors of cardiac arrest in general. As a result there were a large number of variables included in the initial model. Because the previously discussed tests did not demonstrate a significant correlation between many of the predictors and the response of interest (e.g., comorbidities were not significant predictors), it is likely that these variables, despite a possible relationship with cardiac arrest, do not have a direct correlation to CPC after OHCA. This finding resulted in the majority of the predictor variables in the initially proposed model to be excluded. The remaining significant variables included initial $ETCO_2$, $ETCO_2$ after ROSC, highest $ETCO_2$, and lowest $ETCO_2$. These variables were tested for covariance so that if any correlations were present the model could be adjusted.

Covariance was assessed using a visual inspection of a scatterplot matrix. There was a correlation between highest $ETCO_2$ and the $ETCO_2$ after ROSC. This correlation is due to the fact that the $ETCO_2$ noted after ROSC was typically seen to also be the highest $ETCO_2$ achieved. Due to this association the highest $ETCO_2$ was removed from the model. There was no observed correlation between initial $ETCO_2$ and lowest $ETCO_2$.

When the lowest $ETCO_2$ was included in the logistic regression model, it was not a significant predictor ($p=0.997$) and was therefore removed to create the best-fit. The final model, therefore, only includes initial $ETCO_2$ ($p=0.027$) and $ETCO_2$ after ROSC ($p=0.007$). The model indicates that a higher initial end-tidal and a lower end-tidal after ROSC would be correlated to a positive neurological outcome.

While this study demonstrates a definite correlation between $ETCO_2$ and CPC, it does not establish the exact $ETCO_2$ values that correlated to a positive or negative neurologic outcome. Further testing needs to be performed to ascertain at precisely what level of $ETCO_2$ a negative outcome is the result. This data could then be incorporated into the criteria for whether CPR should be performed on a patient suffering from OHCA.

Once a numeric value of $ETCO_2$ can be tied to a poor neurological outcome, better predictions concerning which patients are most likely to respond to intervention will help save resources. This finding would help to decrease family expenses, pre-hospital and hospital resources, as well as suffering of families of loved ones that undergo prolonged resuscitation attempts.

G. Limitations

There were several possible limitations of the study. The first is that the $ETCO_2$ monitor was only calibrated 2-3 times per year unless a problem arises. Due to the limited calibrations there is the possibility that un-calibrated data could skew some of the results slightly. The monitor is used on a daily basis, however, and crews should report any problems so that the monitor can be removed from service for maintenance/repair.

Second, although all EMS staff is trained and credentialed in the use of manual ventilation, there is variability from operator to operator to maintain consistent minute ventilation using a bag-valve mask. To solve this problem in the future, an automatic ventilator should be attached to the endotracheal tube to control tidal volume and rate.

Next, the CPC is a subjective set of very broad categories. Each physician assessing the patient to determine their CPC score may perceive certain disabilities differently. This objective scoring could result in separate physicians assigning two patients with the same outcome different scores. Also of concern is the fact that a pre-arrest CPC score is not available. Thus, if the patient had a CPC score of 4 prior to the event, then the event itself was not a cause of that outcome. In future research a more precise scoring rubric needs to be designed for use in this field as well as collecting a pre-arrest CPC score.

Lastly, the cases where $ETCO_2$ data are missing are a potential source of bias in terms of excluding possibly relevant cases from this study. It is unknown why the data are missing. The missing data could be because of equipment malfunction or unavailability, or the corruption of the file when it was uploaded to the system. The missing data could also be because the EMS personnel on scene forgot or chose not to use the equipment, which is not in adherence to protocol [5]. This limitation is mitigated by the large sample included in the study and the fact that such errors are likely to be distributed randomly across the large sample.

H. Conclusions

This study demonstrates that there is a relationship between initial $ETCO_2$, $ETCO_2$ after ROSC and CPC score in OHCA. Consequently, further research needs to be performed to establish the numeric value of $ETCO_2$ that predicts a positive or negative outcome after OHCA. Future studies should address daily $ETCO_2$ calibration, automated ventilation to control for manual variance, the lack of CPC score prior to the cardiac arrest, and the broad, subjective CPC scores in general.

III. Internship Experience:

A. Description of Site

I am conducting research during my six month internship practicum at MedStar Mobile Healthcare (MedStar) while under the guidance of Dr. Steve Davis, MD. MedStar is a public utility model emergency medical service system that services 880,000 residents of Fort Worth, Texas and fourteen surrounding cities. Dr. Davis is the director of the ICU at John Peter Smith Hospital and is currently serving as the Interim Medical Director at MedStar. He will resume his role as Assistant Medical Director when a new permanent medical director for the system is chosen.

B. Site Experience

I have been interning at MedStar Mobile Healthcare since June 2, 2014. My first month was spent learning site orientation for Fort Worth and its research partner site in Dallas where the Resuscitations Outcome Consortium (ROC) is located. I was introduced to the personnel with whom I would be working at both locations. The key studies in which MedStar is participating are The Cardiac Arrest Registry to Enhance Survival (CARES) in conjunction with the Center for Disease Control and Prevention (CDC), and the Amiodarone, lidocaine or placebo for out-of-hospital cardiac arrest due to ventricular fibrillation or tachycardia (ALPS) with ROC. I performed mandatory training for the ROC study so as to have appropriate IRB approval and learn the process to collect and enter data. The ROC holds a weekly IRB meeting that I am required to attend at least once a month. MedStar is also currently conducting multiple smaller research projects internally involving cardiac arrest that I have assisted with data collection on.

After initial training one of my primary responsibilities has been to collect data for the CARES registry. The CDC is using the data gathered from communities to discover practices that could improve emergency care and survival in OHCA. I have learned the information used for CARES, ROC and my practicum report have a large overlap. Most current studies about OHCA are to reduce cost of care and to help improve survivability; this overlap is therefore expected.

Further involvement throughout my internship was continued data collection for both key studies as well as assisting smaller developments that MedStar is pursuing on their own. My mentor, Dr. Davis, would also like me to present my practicum report as an abstract at a future conference as well as publish in a medical journal. I will be working to finalize these requests shortly after my defense is complete.

C. Journal Summary

The day-to-day activities at my internship are outlined in my daily journal included in the appendix. The initial part of my internship involved me getting acquainted with the staff with whom I would be working and the studies on which I would be working. I had to undergo a large amount of training to be able to assist with all the projects on which MedStar was working with multiple different healthcare institutes. The main studies with which I was to assist were the Amiodarone, Lidocaine, Placebo Study with the Resuscitations Outcome Consortium and the Cardiac Arrest Registry to Enhance Survival with the CDC. During this time I also discussed ideas for my practicum project for my site mentor, Dr. Davis.

The second portion of my internship largely included working on getting my research proposal written and approved. Because the project was already approved by the IRB with which MedStar is affiliated (UTSW), reciprocity for the protocol had to be established with UNTHSC, and the appropriate forms were filed. I applied for an expedited approval due to the fact that it was a chart review and would present minimal risk to the patients involved. I received IRB approval from UNTHSC on October 2, 2014. During this time I was a part of the data collection and entry for the two main studies previously mentioned. I also helped to study trends about cardiac arrests within the MedStar system that were going to be used for internal purposes.

The last portion of my internship was spent collecting data and writing my practicum report. I was able to assist with all the projects with which I had been involved during this time as well, but in a limited manner. I had multiple meetings with my major professor and others who assisted in finalizing my research. I also had to dedicate time to preparing the correct documents needed for graduation.

Appendix

A. Daily Journal

6-2-14

Introduced to staff and toured work space. Reviewed FDA 24 CFR 11 and it's importance to documentation. Taught about patient enrollment forms and pre-hospital forms on ROC (Resuscitation Outcomes Consortium) website. Observed actual forms being filled out online by mentor. Contacted personnel responsible to start approval to be on current IRB's so that I may be included in research activities. Met with ROC representative. Attended staff meeting.

6-3-14

Instructed on CPR process forms and pre-hospital time record forms for ROC. I was taught how to review a cardiac arrest case and what the important data included is. I was taught how ECG rhythms used in data analysis. Observed how to do the form entry process for entire cardiac arrest case that was worked by EMS crew and then pronounced on scene. These forms are input online and kept in ROC database.

6-4-14

Observed how to do entry forms for a patient in cardiac arrest that is transported to the hospital. These forms are input online and kept in ROC database.

6-5-14

I was taught how to retrieve cardiac arrest files from an ambulance monitor. Assisted in tracking down monitors and ambulances to retrieve cardiac arrest files.

6-6-14

Learned how to enter an ALPS (Amiodarone Lidocaine Placebo Study) case on ROC. These forms are input online and kept in ROC database. Collected CPR data files from the ambulance.

6-9-14

IRB training for John Peter Smith

6-10-14

ROC training.

6-11-14

IRB training Texas Health Resources.

6-12-14

Plaza IRB training.

6-13-14

Cardiac arrest compilation of CPR statistics for May including date of event run number, time CPR puck was placed on the patient, the compression rate, average compression depth percentage, average compression count, flow time percent and if the LUCAS device was used.

6-16-14

Cardiac arrest compilation of CPR statistics for April. Same data collected as was used for May.

6-17-14

Learned how to enter data on CARES (Cardiac Arrest Registry to Enhance Survival). Information included in database includes cases where a patient was in cardiac arrest. The data are the patient name, date of birth, medical history, race, sex, address and type of location where arrest occurred, date of event, incident number, first responder organization, destination hospital, if arrest was witnessed, who initiated CPR, if an automated CPR device was used, first monitored arrest rhythm, the end of event status, when/if return of spontaneous circulation (ROSC) occurred, if automated CPR feedback device was used, if advanced airway was placed, if an IV/IO was placed, if and what drugs were given, and the hospital outcome. Site meeting with committee.

6-18-14

Assisted with CARES data entry.

6-19-14

Assisted with CARES data entry.

6-20-14

Helped compile data to show if a patient that was in cardiac arrest and obtained ROSC still had a pulse when arrived at the ED, and if so what the heart rate and blood pressure were at the time care was transferred to hospital staff. Also included what hospital the patient was transported to.

6-23-2014

Entered CARES data. Complied data for June 1-22, 2014 for thesis. Data included run number, if transported, hospital transported to, age, sex, race, past medical history, if epinephrine, sodium bicarbonate or ALPS were given, beginning rhythm, rhythm at ED, time of ROSC, preclinical ROSC time, initial CO2, CO2 before ROSC, CO2 after ROSC, CO2 at ED, highest and lowest CO2, CO2 at 5, 10, 15, 20 and 25 minutes, if a LUCAS was used, if arrest was witnessed, if bystander CPR was done, approximate downtime before EMS arrival, and CPC score.

6-24-14

Worked with Texas Health Harris Fort Worth Collaborative on possible new research project they would like to undertake. Helped perform tasks associated with possible research and performed dry runs in data collection to see if new device was plausible to be used by multiple different agencies and then merged.

6-25-14

CARES data entry. Data collected for May 1-24, 2014 for thesis.

6-26-14

CARES data entry. Data collected for May 25-31, 2014, April 1-30, 2014 and March 1-15, 2014 for thesis.

6-27-14

CARES data entry. Data collection for thesis from March 16-31, 2014 and February 1-15,2014.

6-30-14

CARES data entry. Data collected for thesis from February 16-28, 2014 and January 1-31, 2014. CARES final vital statistics updated for as many patients as could be found on the medical examiner website.

7-1-14

ROC IRB meeting in Dallas. Discussed the progress of each department participating in collection and performance. Discussed IRB transitions and issues needing to be addressed.

7-2-14

CARES data entry. Cardiac arrest compilation of CPR statistics for June including date of event run number, time CPR puck was placed on the patient, the compression rate, average compression depth percentage, average compression count, flow time percent and if the LUCAS device was used. Excel file for missing vital statistics for each hospital filled out so that we may contact them this week and they will have time to respond next week before the July board meeting in 2 weeks.

7-3-14

Conducted literature review for thesis. Worked on research proposal. Meeting with Dr. Davis to discuss progress and sign off on daily journal.

7-4-14

Holiday

7-7-14

CARES data entry. Conducted literature review for thesis. Attended weekly staff meeting.

7-8-14

CARES data entry. Worked on research proposal.

7-9-14

CARES data entry. Worked on research proposal.

7-10-14

CARES data entry. Interviews for new medical director within office. Worked on research proposal.

7-11-14

CARES data entry. Conducted literature review for thesis. Worked on research proposal.

7-14-14

CARES data entry. Worked on research proposal. Attended weekly staff meeting.

7-15-14

CARES data entry. Worked on research proposal.

7-16-14

CARES data entry. Worked on research proposal.

7-17-14

CARES data entry. Worked on research proposal.

7-18-14

CARES data entry. Worked on research proposal. Assessed cardiac arrest data gathered for past 3 months to make sure it is accurate for upcoming board meeting.

7-21-14

CARES data entry. ROC data entry. Worked on research proposal. Attended weekly staff meeting.

7-22-14

CARES data entry. ROC data entry. Worked on research proposal.

7-23-14

CARES data entry. ROC data entry. Worked on research proposal.

7-24-14

CARES data entry. ROC data entry. Worked on research proposal. Meeting with Dr. Davis to discuss status of research and sign off on research log.

7-25-14

CARES data entry. ROC data entry. Worked on research proposal.

7-28-14

CARES data entry. Weekly staff meeting. Worked on research proposal.

7-29-14

CARES data entry. ROC IRB meeting.

7-30-14

CARES data entry. Worked on research proposal.

7-31-14

CARES data entry. Worked on research proposal.

8-1-14

CARES data entry. Cardiac arrest compilation of CPR statistics for July including date of event run number, time CPR puck was placed on the patient, the compression rate, average compression depth percentage, average compression count, flow time percent and if the LUCAS device was used. Excel file for missing vital statistics for each hospital filled out.

8-4-14

CARES data entry. Cardiac arrest compilation of CPR statistics for last half of July. Worked on research proposal. Staff meeting.

8-5-14

CARES data entry. Compilation of data for patients in cardiac arrest transported with or without a pulse for July.

8-6-14

CARES data entry. Data collection for January 2014.

8-7-14

CARES data entry. Meeting with Dr. Davis to discuss research.

8-8-14

CARES data entry. EKG data collection for thesis.

8-11-14

CARES data entry. EKG data collection for thesis. Staff meeting.

8-12-14

CARES data entry. EKG data collection for thesis.

8-13-14

CARES data entry. EKG data collection for thesis.

8-14-14

CARES data entry. EKG data collection for thesis.

8-15-14

CARES data entry. EKG data collection for thesis.

8-18-14

CARES data entry. EKG data collection for thesis. Staff meeting.

8-19-14

CARES data entry. EKG data collection for thesis.

8-20-14

CARES data entry. EKG data collection for thesis.

8-21-14

CARES data entry. EKG data collection for thesis. Meeting with Dr. Davis.

8-22-14

CARES data entry. EKG data collection for thesis.

8-25-14

CARES data entry. EKG data collection for thesis. Staff meeting.

8-26-14

CARES data entry. ROC IRB meeting.

8-27-14

CARES data entry. EKG data collection for thesis.

8-28-14

CARES data entry. EKG data collection for thesis.

8-29-14

CARES data entry. EKG data collection for thesis.

9-1-14

Labor Day.

9-2-14

CARES data entry. EKG data collection for thesis.

9-3-14

CARES data entry. EKG data collection for thesis.

9-4-14

CARES data entry. EKG data collection for thesis. Meeting with Dr. Davis.

9-5-14

CARES data entry. EKG data collection for thesis.

9-8-14

CARES data entry. EKG data collection for thesis.

9-9-14

CARES data entry. EKG data collection for thesis. Staff meeting.

9-10-14

CARES data entry. Cardiac arrest compilation of CPR statistics for May including date of event run number, time CPR puck was placed on the patient, the compression rate, average compression depth percentage, average compression count, flow time percent and if the LUCAS device was used.

9-11-14

Compilation of data for patients in cardiac arrest transported with or without a pulse for August. Excel file for missing vital statistics for each hospital filled out.

9-12-14

CARES data entry. EKG data collection for thesis.

9-15-14

CARES data entry. EKG data collection for thesis. Staff meeting.

9-16-14

CARES data entry. EKG data collection for thesis.

9-17-14

CARES data entry. EKG data collection for thesis.

9-18-14

CARES data entry. EKG data collection for thesis.

9-19-14

CARES data entry. EKG data collection for thesis. Work on IRB approval form.

9-22-14

EKG data collection for thesis. Staff meeting. Work on IRB approval form.

9-23-14

IRB form submission. ROC IRB meeting.

9-24-14

Scanning of documents into electronic file system.

9-25-14

Scanning of documents into electronic file system.

9-26-14

Scanning of documents into electronic file system.

9-29-14

Staff meeting. Scanning of documents into electronic file system. Research on how to use SPSS software.

9-30-14

Scanning of documents into electronic file system. Research on how to use SPSS software.

10-1-14

Scanning of documents into electronic file system. Research on how to use SPSS software.

10-2-14

Scanning of documents into electronic file system. Research on how to use SPSS software.

10-3-14

Scanning of documents into electronic file system. Research on how to use SPSS software.

10-6-14

Staff meeting. Scanning of documents into electronic file system. Statistical data clean up for analysis.

10-7-14

IRB approval received from UNTHSC. Scanning of documents into electronic file system. Statistical data clean up for analysis.

10-8-14

Scanning of documents into electronic file system. Statistical data clean up for analysis.

10-9-14

Scanning of documents into electronic file system. Analysis of thesis data.

10-10-14

Scanning of documents into electronic file system. Analysis of thesis data.

10-13-14

Staff meeting. Scanning of documents into electronic file system. Analysis of thesis data.

10-14-14

Scanning of documents into electronic file system. Analysis of thesis data.

10-15-14

Scanning of documents into electronic file system. Analysis of thesis data.

10-16-14

Scanning of documents into electronic file system. Analysis of thesis data.

10-17-14

Scanning of documents into electronic file system. Analysis of thesis data.

10-20-14

Staff meeting. Scanning of documents into electronic file system. Meeting with tutor for SPSS software guidance.

10-21-14

Scanning of documents into electronic file system. Meet with tutor for SPSS software guidance.

10-22-14

Scanning of documents into electronic file system. Meet with tutor for SPSS software guidance.

10-23-14

Scanning of documents into electronic file system. Prepare final practicum report.

10-24-14

Scanning of documents into electronic file system. Prepare final practicum report.

10-27-14

Staff meeting. Scanning of documents into electronic file system. Prepare final practicum report.

10-28-14

ROC IRB meeting. Prepare final practicum report.

10-29-14

Scanning of documents into electronic file system. Prepare final practicum report.

10-30-14

Scanning of documents into electronic file system. Prepare final practicum report.

10-31-14

Scanning of documents into electronic file system. Prepare final practicum report.

11-3-14

Staff meeting. Submission of practicum report to all committee members. Scanning of documents into electronic file system.

11-4-14

Edits to thesis. Scanning of documents into electronic file system.

11-5-14

Prepare thesis defense presentation.

11-6-14

Prepare thesis defense presentation.

11-7-14

Prepare thesis defense presentation.

11-10-14

Staff meeting. Prepare thesis defense presentation.

11-11-14

Prepare thesis defense presentation.

11-12-14

Prepare thesis defense presentation.

11-13-14

Prepare thesis defense presentation.

11-14-14

Prepare thesis defense presentation.

11-17-14

Thesis defense.

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