Addis Ababa University

College of Health Sciences

School of Medicine

Department of Emergency medicine and Critical care

Emergency Medicine and Critical care Resident's Competency to Identify Patient Ventilator Asynchrony Using Mechanical Ventilator Waveforms Analysis in Addis Ababa, Ethiopia.

A research Thesis Summited to Addis Ababa University, college of health sciences, School of Medicine, Department of Emergency Medicine In Partial Fulfillment of Requirements for Post Graduate Specialty certificate in Emergency Medicine and Critical Care

Investigator: Wegderes Bogale (MD, EMCC PGY-3)

Advisers: Dr. Finot Debebe (MD, Associate professor of EMCC)

Dr. Merahi Kefyalew (MD, Assistant Professor of EMCC)

January, 2024

Addis Ababa, Ethiopia

Principal Investigator	Dr. Wegderes Bogale
Title of the research	Assessment Of Emergency Medicine and Critical Care (EMCC) Resident's Competency to Identify Patient Ventilator Asynchrony Using Mechanical Ventilator Waveforms Analysis
Study area	Saint Paul Hospital and Tikur Anbesa hospital,
Source(s) of funding	AAU,CHS
Phone number of investigator	Tel: +25191557062
	Email: wegbogale62@gmail.com
advisors	Dr. Finot Debebe and Dr. Merahi Kefyalew

ACRONYMS AND ABBREVIATIONS

AAU –Addis Ababa University

CCU – Cardiac Critical Care Unit

CHS –college of health Sciences

EMCC-Emergency medicine and critical care

ED - Emergency Department

ETB - Ethiopian Birr

GP – General Practionier

ICU –Intensive Care Unit

IQR-interquartile range

IRB - Institutional Review Board

MD - Medical Doctor

MICU - Medical Intensive Care Unit

PEEP- Positive End Expiratory Pressure

PVA - Patient Ventilator Asynchrony

SICU –Surgical ICU

SPHMMC -Saint Paul Hospital Millennium Medical College

TASH – Tikur Anbessa Specialized Hospital

ACKNOWLEDGEMENT

I acknowledge AAU, CHS, Emergency Medicine and critical Care department for paving the way for this thesis experience, which would have a contribution for my academic and clinical competency. I want to thank Dr.Finot, Dr.Ikram, and Dr.Tolosa for helping me standardize the mechanical ventilator waveforms. I would also like to thank my advisors for their continuous support and critics, EMCC residents for their participation in the research and my friend, Dr.Amir Muhidin and finally family for their constant support.

TABLE OF CONTENTS

LISTS OF TABLES AND FIGURES

ABSTRACT

Background: patient ventilator asynchrony (PVA) is a condition where there is suboptimal interaction between patient and mechanical ventilator. It is common and often undetected with negative impact on patient's outcome if unrecognized and addressed. Mechanical Ventilator waveforms analysis is a non-invasive and reliable way of recognizing PVAs where advanced methods of identifying PVA are lacking, however it has not been well studied on residents working in poor setups.

Objectives: to assess emergency medicine and critical care residents' competency and its associated factors to identify PVA by using mechanical ventilator (MV) waveform analysis in Saint Paul Hospital Millennium Medial College (SPHMMC) and Tikur Anbesa specialized hospital (TASH).

Methodology: two centers cross sectional study was done among senior EMCC residents in-training at TASH, and SPHMMC, Addis Ababa, from October to November 2023. All 91 senior EMCC residents were enrolled. A pretested and structured self-administered questionnaire was using an adopted and internally modified assessment tool. The completed data was collected via web link after being prepared by kobtoolbox.org, coded, manually checked, and exported to version 27 SPSS analysis. Descriptive statistics, chi square test, nonparametric tests and multi variable logistic regression were used to analysis of data.

Results –Eighty senior residents responded out of 91, 42 from TASH and 38 from SPHMMC. The overall competency of identifying PVA by MV waveforms is 30%. A median of 3 (IQR 1-4) PVAs were correctly identified. Only 1 resident (1.25%) identified all 6 different types of PVAs,;(8.75%) identified 5 PVAs,; 20% identified 4 PVAs,; 22.5% identified 3 PVAs,; 17.5% identified 2 PVAs,; 13.75% identified Correctly 1 PVA and 16.25% did not identify any PVA. Auto PEEP was the most PVA identified, and delayed cycling was the least PVA identified. Year of residency, being a TASH resident and presenting or attending seminar on MV waveforms were associated with identifying ≥4 PVAs.

Conclusion: The overall competency of identifying PVA by MV waveforms is low among EMCC residents. Higher years of residency, and presenting or attending seminar on mechanical ventilation (MV) were associated with competency of identifying PVAs by MV waveform analysis.

1. INTRODUCTION

1.1.Background

Respiratory failure is common organ failure found in severely ill patients (1). Mechanical ventilation (MV) is required for the majority of these patients in order to reduce maintain adequate oxygenation and ventilation as well as offloading respiratory work (1).

It was in 1970 the term “fighting ventilator” first used to describe patient ventilator asynchrony (2). Patient-ventilator interaction is characterized as the interplay between two controllers: the physician-controlled ventilator and the patient's inherent respiratory control. For the patient-ventilator interaction to be effective for the patient, these two controllers need to be in sync. Patient-ventilator asynchrony refers to any situation where the interaction between the ventilator and patient is suboptimal. (3).

Patient ventilator asynchrony can occur during inspiration or expiration phase, during inspiration it can happen during trigger(e.g. auto triggering, ineffective triggering),flow or during cycling like delayed or premature cycling),auto PEEP is expiratory PVA (4). A study revealed that among the mechanically ventilated patients examined, 24% experienced various types of patient-ventilator asynchrony (PVA). Double triggering being the most common, reported in 13% of the cases. The second most frequent occurrences were both cycle mismatch and ineffective effort, each accounting for 4% of the cases. Delayed triggering had the lowest incidence, observed in only 1% of the patients. It is common to see double triggering in volume controlled than pressure controlled ventilation(5).There is a growing evidences that several of these asynchronies could cause eccentric contractions, over- or under-assistance from the ventilator, or diaphragmatic myotrauma with significant negative clinical effects, including as discomfort for the patient, diaphragmatic weakening, extended mechanical ventilation, and lower survival(6). Ineffective triggering, often brought on by auto PEEP is linked to extended stay on MV and higher mortality, for instance (7). So, early identification and management of PVAs are essential steps of managing patients on mechanical ventilation.(8)

There are many tools available to evaluate asynchrony. Esophageal pressure measurement and diaphragmatic electrical activity assessment by electromyography have been regarded as the best techniques for identifying asynchrony (9) .However, because they are intrusive and expensive, they are rarely used in routine clinical practice, especially in developing nations like Ethiopia. However, utilizing waveforms, which are graphical forms of patient-ventilator interaction is not only a trustworthy alternative method that is non-invasive, but it has also demonstrated a good connection with the invasive procedures (10). Mechanical ventilator waveforms give real time graphical view how the patient is interacting with ventilator and give insight in to management by manipulating ventilator set-up.

1.2.Statement of the problem

Patient ventilator asynchrony is a really common problem, occurring around 25% of patients on MV(7). Mechanical ventilator Waveforms are readily available for real-time, can be interpreted within seconds, and are noninvasive, having invaluable role for detecting common types of PVAs. Healthcare providers, such as EMCC residents, who deal with mechanical ventilation, require competence in waveform analysis and its clinical application. This is crucial due to the significant negative clinical consequences associated with patient-ventilator asynchrony, including patient discomfort, longer days on mechanical ventilation, and increased mortality. Therefore, their competency in this area is undeniably important. Despite being difficult in accurately identifying patient-ventilator asynchrony, the inspection of pressure/time and flow/time mechanical ventilator graphics seen on the ventilators screen remains the most common method available for recognizing specific types of PVAs. However, studies conducted abroad have shown low rates of identifying PVA through waveform analysis, with prior training on MV including waveforms being the sole significant factor in correctly identifying patient-ventilator asynchrony. Both experience and profession were found to be insignificant factors to identify PVA through waveform analysis (11) .

There have been no published studies in our country examining the competencies of EMCC residents in waveform analysis and the factors associated with identifying patient-ventilator asynchrony.

1.3 Significance of Study

This study’s findings gave us more information on EMCC residents’ competency and the associated factors in identifying patient ventilator common asynchronies by analyzing waveforms they face in the emergency room as well as ICU.

As the first study in this area in our country, it will have a subsequent impact on improving patients care on MV and future researches on this area. In addition, study gave recommendation to department on areas of improvement on resident's performance in waveforms analysis to identify PVA. Furthermore, it is expected our study will have impact on quality improvement projects and ICU protocols.

1.4. Literature review

In 2017, study took place in 25 hospitals, specifically in 17 urban ICUs in Chile. The study involved 366 health care workers in ICUs, including nurse, respiratory therapists and physicians, and, to study factors influencing the competency of identifying PVAs using MV waveforms analysis. A comparison was made between those having training on MV those who don't have, health care professionals(HCPs) based on their ability to accurately detect asynchronies(12). Health care professionals with prior training in mechanical ventilation had approximately four times higher odds of accurately identifying two or more asynchronies. Additionally, those with training on MV had odds of accurately recognizing 2 or more asynchronies that were approximately four times higher. However, their competency to identify PVAs was not correlated with years of experience or occupation (12).

A Similar research was done in Saudi, 2020 to study competency of critical care practitioners (CCPs) including respiratory therapists (RTs), nurses, and doctors, to identify patient ventilator asynchrony (11). Of the 411 CCPs evaluated, only 10.2% identified all the 3 PVAs types, 22.4% identify 2 PVAs and 42.3% could identify one PVA correctly and remaining 25.3% could not recognize any (11). The only predictor of identifying PVAs were training and female gender; profession, hospital characters and experience were not associated with PVA identification ability (11).

In a similar study conducted in twenty countries in 2021, on 431 ICU healthcare professionals with six waveforms. A median 4(IQR1-5) PVAs identified and only 19.5% of them identified all six waveforms 56.8% could identify ≥4 PVAs, furthermore 3% didn't identify any PVA. Training on MV, working in SICU, CICU were predictors of competency on identification of PVA (13).

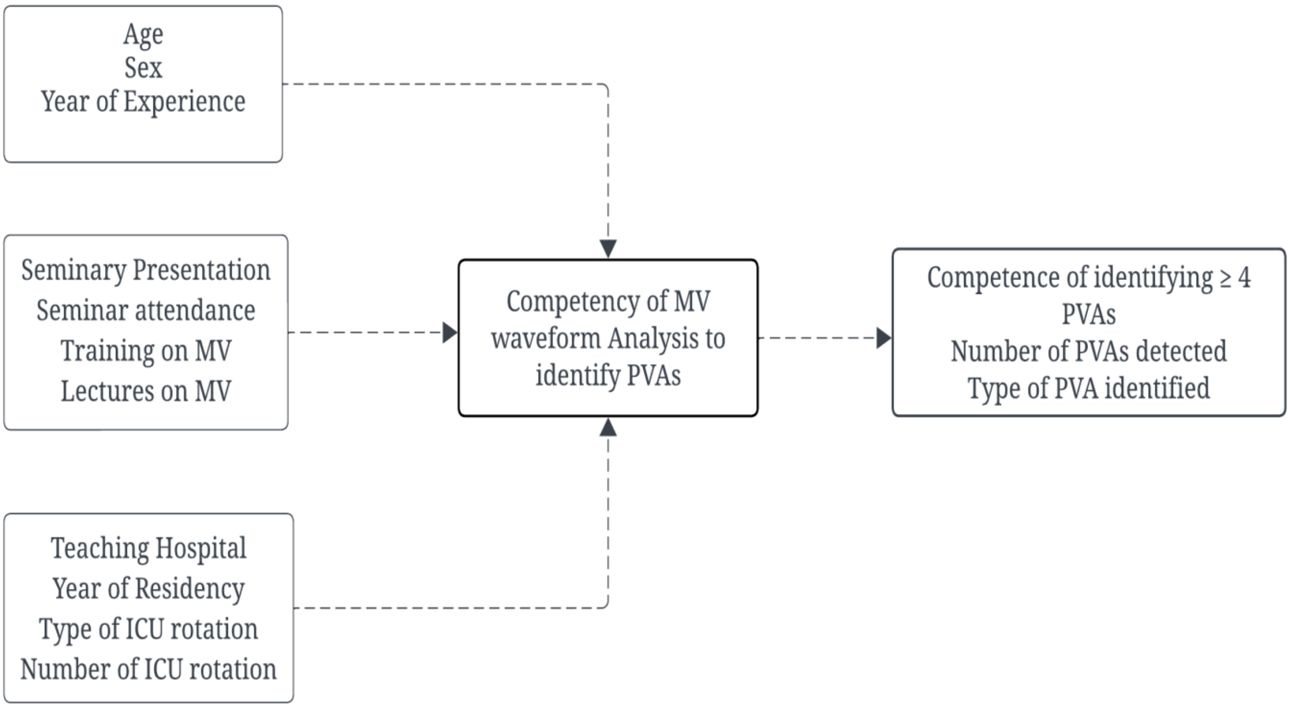
A study done between July 2016 and January 2019, on 93 on pulmonology and critical care medicine (PCCM) and critical care medicine (CCM) fellows from 10 fellowship programs who completed the examination on mechanical ventilator (MV) waveforms (14). Twenty fellows who trained at three fellowship programs was control group and had 23 months of training at time of MV examination(15). Prior to the course, the fellows' scores in MV waveform analysis was low but showed improvement after three day course at the beginning of the fellowship(15). These findings aligned with previous research indicating targeted and dedicated training needed to enhance knowledge on MV waveforms.

As per our knowledge Published related studies on EMCC resident's skills in ventilator's graphics monitoring to identify asynchronies are null in Africa but there is one study done in Egypt on Critical care Nurses and there finding was 88% of participants were having poor knowledge on MV waveforms(16).

There haven't been any published publications in Ethiopia up to this point about the assessment of EMCC residents' comptency in mechanical ventilator waveform analysis for PVA identification

1.5 Conceptual framework

Figure 1 The study's conceptual framework: The Relationship between Competency to Identify PVA and Associated Factors (11-13)



3. OBJECTIVE

3.1. General Objective

The study aims to assess EMCC residents' competency and associated factors to identify patient ventilator asynchrony by analyzing mechanical ventilator waveforms in TASH and SPHMMC.

3.2. Specific objectives:

1. Assessing competency of EMCC residents at SPHMMC and TASH on waveform analysis to identify patient ventilator asynchrony.
2. To identify factors associated with competency in mechanical ventilator waveform analysis to identify patient ventilator asynchrony among EMCC residents in TASH and SPHMMC.

4. METHDOLOGY

4.1. Study settings, area and period:

The study was carried out in October–November 2023 at TASH and SPHMMC, both of which are in Addis Ababa, the capital city of Ethiopia, which is situated in the country's central region. TASH is one of the pioneer hospitals in Ethiopia, established in 1972 GC located in Lideta sub city. Emergency department began a three-year residency program in October 2010 and provides services mainly in emergency room.

At TASH, there are few mechanical ventilators in the emergency room, run by the EMCC department. EMCC residents intubate patients and deliver care till they are transferred to ICU. There is one main ICU, which consists of six medical, four PICU, and six surgical ICU beds. EMCC residents do have rotations to each ICUs including Zewditu Memorial Hospital’s ICU, one of government hospitals the city having 10 beds during their training stay. The trainings are given by consultants attending at both set-ups.

Under governance of federal ministry of health SPHMMC was established in 2010,and emergency medicine and critical care department in the year 2011 G.C. Addis Ababa Burn Emergency and Trauma Hospital (AaBET) ICU, which has 12 beds, is run by the SPHMMC EMCC department. The main ICU at SPHMMC has 13 beds.

4.2. Study design:

Two centers institutional-based cross-sectional study

4.3. Population:

4.3.1. Target population:

All EMCC residents in Ethiopia

4.3.2. Source population:

All EMCC residents of TASH and SPHMMC

4.3.3. Study population:

All senior EMCC residents of TASH and SPHMMC

4.3.4. Study unit:

Each EMCC senior residents of TASH and SPHMMC

4.3.5. Sampling frame

List of senior EMCC residents who were at their training during the time of study participate in the respective teaching hospitals.

4.4. Eligibility criteria

4.4.1. Inclusion criteria:

All senior EMCC residents attending their residency program at TASH and SPHMMC at time of study

4.4.2. Exclusion criteria:

All First and 2nd year EMCC residents who didn't complete 6 months of 2nd year and residents who were not willing or were not were at their training the time of study for reasons including illness, month off, and maternity leave.

4.5. Sample size determination and sampling technique

4.5.1 Sample size

Single population proportion formula for cross-sectional study used to calculate sample size

$$n= (z\alpha/2)^2 p (1-p)/D^2$$

n is the minimum required sample size, $Z\alpha/2$ is the value under the standard normal table for a given confidence interval (1.96 for 95% CI), p is the best estimate of prevalence since we don't have a previously done study in our country, we took 50%, and d is the margin of error (0.05). Calculated sample size was 82.Since calculated sample size and study population doesn't have significant difference; all 91 senior EMCC residents were enrolled.

4.5.2. Sampling technique and procedures:

The teaching hospitals (TASH and SPHMMC) were selected by purposive sampling. After having lists of all 91 residents from each teaching hospital, they were enrolled.

Table 1: Allocation of Study Participants, n=91

	TASH	SPHMMC
R2	25	19
R3	19	28

4.6. Study Variables:

4.6.1 Dependent variable:

Primary outcome

Competency of identifying ≥4 PVAs

Secondary outcomes

Number of PVA identified

Type of PVA identified

4.6.2. Independent variables:

- ✓ Age,
- ✓ sex,
- ✓ Teaching hospital,
- ✓ year of experience
- ✓ ICU working experience as a general practitioner.
- ✓ Year of residencies
- ✓ Presenting or attending seminars on MV
- ✓ Training on mechanical ventilation
- ✓ Lectures on mechanical ventilator
- ✓ Attending all lectures
- ✓ Number of hours dedicated to lectures
- ✓ Number and type of ICU with most rotations

4.7. Operational definitions

Waveforms analysis: visual inspection of a graphical description on mechanical ventilator how breaths are delivered to the patient

Patient ventilator asynchrony : non-optimal patient ventilator interaction

Competency –ability of identifying> 70% or ≥4 of PVAs correctly as per AAU post graduate pass mark (17)

Senior residents: are those in their third year and year two residents who have finished the first half of their second year**.**

MV training: an online or in-person MV course from a recognized institution

Rotation- attaching at ICU in a particular month.

4.8.Procedures on data collection

Data was collected by a pre-tested, structured, self-administered questionnaire prepared by reviewing different related literature considering the objectives. The development of the items of the questionnaire was accomplished by adapting from literature review (13, 18), 14] ,(11) (19) (20) and the adopted study tool underwent the necessary revisions based on recommendations by four experts in the area of critical care. The questionnaire has closed-ended and some open ended questions, including Sociodemographic characteristics, basic information about residents, and mechanical ventilator waveforms of PVAs. The questionnaire is prepared in English. Informed consent, in written form, was obtained before data collection. The questionnaire was prepared by software koboToolbox.org and shared via online link provided by koboToolbox.org to their email or telegram for each resident. Data was collected from those residents who were cooperative in giving consent.

The waveforms consisted of six different common waveform pictures of scalars of pressure time and flow time, known to have adverse clinical outcome if not corrected in literatures, such as ineffective triggering, **premature cycling**, **auto triggering**, **flow starvation**, **delayed cycling and auto-PEEP.** Waveforms were adopted from a previous study , extracted from web blogs and the puritan Bennett 840 attached to a test lung **(**12**,** 19**)**. The adopted waveform pictures were shown to four different consultants: pulmonologists, cardiac anesthesiologist and intensivist, Emergency Medicine and Critical Care consultant, adult and pediatric pulmonology and critical care fellow. All of them are responsible in their respective hospital in field of critical care. They agreed on the sorts of asynchrony to a hundred percent. The specialist's waveform analysis was used to standardize the web blogs waveforms. After each picture was shown, the residents were asked to choose a type of PVA from multiple choices from 12 possible choices. The TASH data collector was main investigator, while another data collector supplied the SPHMMC data. Before finishing data collection, the data's completeness was verified. Pretest was done on 5% of participants.

4.9.Data quality control

The questionnaire was articulated clearly to be understood by respondents. The selected pictures were clear enough. Respondents were required to answer all mandatory questions in order to submit their responses. A pre-test was conducted on three participants who were not part of the main study and internal data reliability was tested by Cronbach's alpha. The pre-test aimed to evaluate the clarity and comprehensibility of the assessment tool. While the data was being collected, regular supervision was provided to the data collector to monitor the data collectors' adherence to the study protocol, address any challenges they encountered, and ensure the overall quality of the data being collected. To reduce the guessing effect, the possible choices are 12 for 6 waveforms. Most data was collected while respondents were gathered while the data collector was there. The data was collected via a link provided by kobotoolbox.org software by using only once per respondent to protect the same user from summiting more than once. Before entering the information into the SPSS program, the responses were reviewed for the comprehensiveness of data.

4.10. Data processing and analysis

Completed da was downloaded from kobotoolbox to excel and exported to version 27 SPSS for analysis. Qualitative nominal variables were represented using absolute and relative (%) values. For non-normally distributed continuous and ordinal data, the median with interquartile range was used. Prior to applying these measures, the normality of the data was assessed using the Shapiro-Wilk test. Independent variable categorical and a primary outcome variable were displayed using frequency tables and cross-tabulations, which were then, assessed using the Fisher's Exact Test or the Chi-Square Test. The median of continuous data between the two groups, dependent variable was compared using non-parametric tests such as Mann Whitney U test. To explore the association between all independent variables and competency of PVA identification, and multivariable logistic regression was done. Identifying ≥4 PVA was considered the dependent variable after the model fitness test was performed using Hosmer and Lemeshow tests. The model's fitness was assessed using the Pearson test, and we took p value of >0.05 to consider as significan.. Binary dependent categorical and continuous variables were analyzed using multivariable binary logistic regression with variables with p value <0.2 included to multivariable logistic regression.Statistical significance was defined by p value of <0.05 and 95 CI.

4.11 **Ethical consideration**.

Before data collection, ethical approval official letter was received from research committee of EMCC department. Informed consent was taken from participants upon filling the questionnaire. Confidentiality was ensured by allowing respondents to fill out the questionnaire anonymously

5. RESULTS

5.1 Responses

Total of 91 invitations online link were sent provided by from kobotoolbox.org to senior EMCC residents of TASH and SPHMMC. 80 residents responded, making response rate 88%.

5.2 Characteristics of study Participants

Total of 80 residents Male 54 (67.5%), Female 26 (32.5%) with a median age of 29 IQR (28-30) years participated. Forty two (52.5%) of the residents were from TASH and 38 (47.5%) were from SPHMMC. Half of the participants were 3rd year and the other half were 2nd year EMCC residents. Only 14 (17.5%) of residents has had worked at ICU as general practitioner. Twenty six residents (32.5%) reported that they had finished a training program in MV, which was specifically designed with a curriculum that covered various topics including PVA and waveforms.

Most have experience in medical practice < 5 years (n=55, 68.8%). All residents had ICU rotation, with median number of rotations being 4 (IQR 2-6) (the mean being 4 for 2nd year and 6 for 3rd year residents).Most of residents ,69 (86.3%) of attend lecture on MV with median of estimated hours for lecture being 2 hours (IQR 2-4) in their residency stay. Of those who attended lectures, 49 (71%) attended all lecture classes but only 43 (62.3%) reported lectures had waveform analysis and PVA among topics.

Sixty residents (75%) presented or attended seminar on MV waveforms 35 from 3rd year 25 from 2nd year and on their stay of residency. Sixty eight residents (85%) had bed side teaching, small group exercise and simulation during their rotation to ICU but large number of them 39(48.8) requiring substantial change. Only two of them rated these activities as outstanding. Most of residents 42(52.5%) are unsatisfied on teaching of waveforms and PVAs. Sixty five (81%) of residents reported a greater number of rotations being MICU or SICU: half of them reported MICU.

Table 2 background characters of study participants (n=80)

Variables	**Frequency**	**Percentage**
Age		
<29	27	33.75
29-30	37	46.25
>30	16	20
Sex		
Male	54	67.5
Female	26	32.5
Teaching hospital		
SPHMMC	38	47.5
TASH	42	52.5
Year of residency		
year 2	40	50
year 3	40	50
Years of experience		
< 5 year	25	31.3
>5 year	55	68.8
Participation in Seminar on waveforms	56	70
ICU work experience as GP	14	17.7
Training on MV	26	32.5
Lectures on MV	69	86.3
Waveform and PVA added	43	62.3
Attending all classes	49	71

5.3 Competency of Identifying PVAs by Waveform Analysis

The overall competency of identifying PVA by MV waveforms is 30 %(< 70% of waveforms) .only 1resident answered all 6 PVAs correctly. A median of 3 (IQR 1-4) PVAs were identified correctly. The distribution of residents on bases of correctly identified PVAs was: one resident (1.25%) identified all 6 different types of PVAs, 7 residents (8.75%) identified 5 PVAs, 16 residents (20%) identified 4 PVAs, 18 residents (22.5%) identified 3 PVAs, 14 residents (17.5%) identified 2 PVAs, 11 residents (13.75%) identified Correctly one PVA and most concerning was the fact that 13 residents (16.25%) couldn’t identify any PVAs . Distribution of residents on bases of type of PVAs identified showed that 61 residents (76.3%) identified Auto PEEP, 39(48.8%), 38 residents (47.5%) identified flow starvation (flow asynchrony) 38(47.5%) identified ineffective triggering, 36(45%) identified auto triggering, 21 residents (26.3%) identified premature cycling, and 15 (18.8%) identified delayed cycling

Table **3 number of PVAs correctly identified**

Number of PVAs identified correctly	**Frequency N=80**	**Percentage**
0	13	16.3
1	11	13.8
2	14	17.5
3	18	22.5
4	16	20.0
5	7	8.8
6	1	1.3

Figure 2: Number of PVAs detected

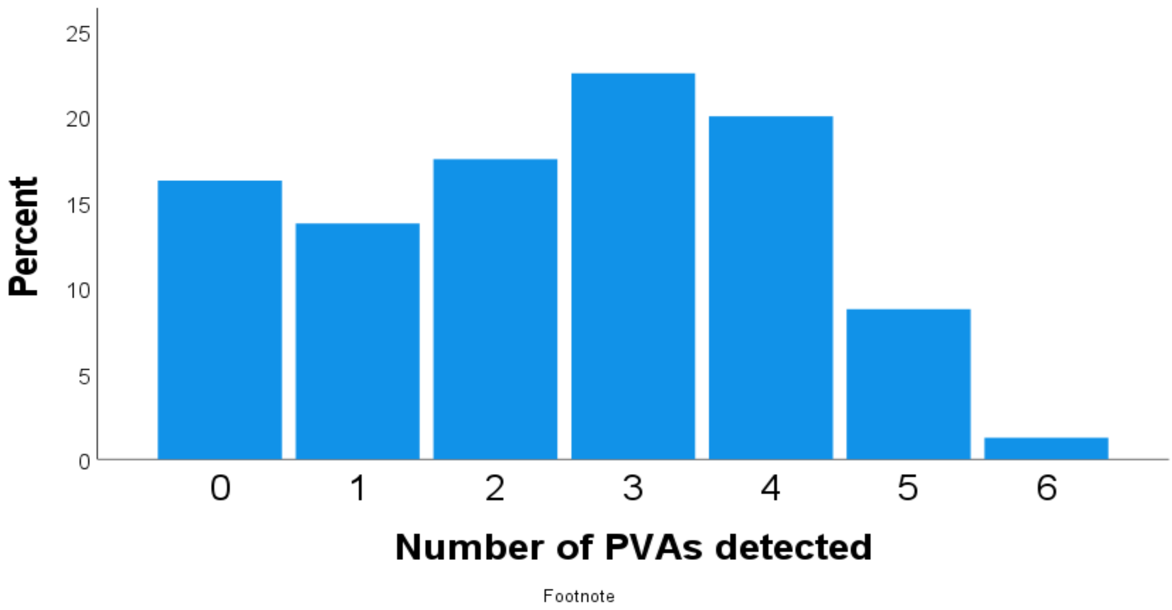
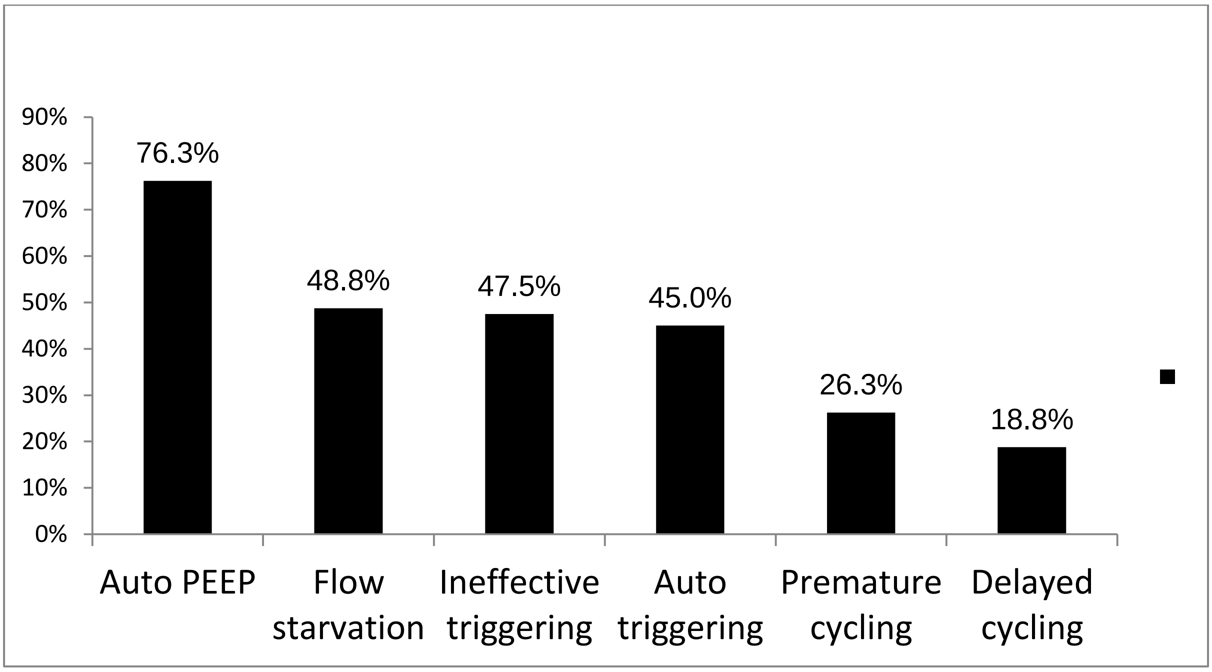


Table 4 patient ventilator asynchronies identified by waveforms

Waveforms	**Correctly answered N=80**	
	Frequency	Percent
Auto PEEP	61	76.3
Flow starvation	39	48.8
Ineffective triggering	38	47.5
auto triggering	36	45
Premature cycling	21	26.3
Delayed cycling	15	18.8

Figure 3: type of PVAs detected



5.4 Factors associated with competence of identifying **≥4** PVAs.

The following table presents the chi square tests/Mann Mann Whitney test of independent variable with primary outcome, competency in identifying PVAs. Multi variable binary logistic regression was performed after chi-square test and nonparametric tests were done to evaluate the effect of being a seminar presenter or attendee on MV waveforms, year of residency and teaching hospital and training on MV which includes PVAs and waveforms on identifying ability of ≥4 PVAs. The goodness of fit test of the model was assed using Hosmer lemeshew test. The data includes crude odds ratios (COR) with 95% confidence intervals.

Among the characteristics examined, being seminar presenter or attendee on MV waveforms (χ^2 of 7.3 with p value =0.005), being a 3rd year resident (χ^2 of 3.8 with p value of =0.05) and teaching hospital being TASH resident (χ^2 of 13.07 with p value of 0.001)of had statistically significant association with identifying ≥4 PVAs on multivariate logistic regression, (see table below) .Residents who are 3rd year residents have 4.2 times higher odds of identifying ≥4 PVAs compared to 2nd year residents (COR=4.2,95 % CI =1.15,15.23, P value =0.03). Residents who has presented or attended seminar on MV waveforms have 13.05 times higher odds of identifying ≥4 PVAs compared to the non-presenter group (COR 13.05,95% CI =1.54,110.5, P value =0.037). Residents from TASH have 7.72 times higher odds of identifying ≥4 PVAs compared to SPHMCC (COR 7.72, 95% CI =2.33, 25.6, P value of =0.001). No significant difference were found when residents were compared by prior training on MV, age, sex, experience in medical practice, attending at least lectures on MV during residency, working in ICU as a general practioner, number and type of ICU rotation with most rotation according to number of PVAs identified correctly. Lack of identification of PVA was significantly higher in 2nd year residents, OR 5.2(1.2-22.4),P value =0.027 ,residents who has never presented or attended seminars on waveforms OR , P value =0.05, female 4.4(1.3-15), P value =0.02.

Table 5 summary table of associated factors with identifing≥4 PVAs, χ^2 test

Variable	Number of PVAs Detected			χ^2 test/**Mann Whitney test**	**P value**
	Total (n=80)	**<4 PVAs**	**≥ 4 PVAs**		
Age(IQR)	29 (28-30)	29 (28 30)	29 (28 - 30)	634.5	0.69
Sex					
Male	54(67.5%)	39(69.6%)	15 (62.5%)	0.39	0.53
Female	26(32.5%)	17(30.4%)	9 (37.5%)		
Teaching hospital					
SPHMMC	38(47.5%)	34(60.7%)	4 (16.7%)	**13.07**	**<0.001**
TASH	42(52.5%)	22(39.3%)	20 (83.3%)		**13.07**
Year of residency					
year 2	40(50.0%)	32(57.1%)	8 (33.3%)		
year 3	40(50.0%)	24(42.9%)	16 (66.7%)	**3.8**	**0.05**
Years of experience					
				3.4	0.065
< 5 year	25(31.3%)	21(37.5%)	4 (16.7%)		
>5 year	55(68.8%)	35(62.5%)	20 (83.3%)		
Participation in Seminar on waveforms	56(70%)	37(66%)	23(41%)	**7.3**	**0.005**
ICU work experience as GP	14(17.7%)	10(18.2%)	4 (16.7%)	0.026	0.87
Training on MV	26(32.5%)	19(33.9%)	7 (29.2%)	0.174	0.67
Lectures on MV	69(86.3%)	51(91.1%)	18 (75.0%)	3.66	**0.05**
Waveform and PVA added among topics	43(62.3%)	31(60.8%)	12 (66.7%)	0.19	0.67
Attendance to classes	49(71.0%)	37(72.5%)	12 (66.7%)	0.22	0.64
Estimated hours for lectures	2(2-4)	2(2-3)	3(2-4)	369	0.209
Number of ICU rotations	4 (2 - 6)	4 (2 - 6)	4 (3 - 6)	629	0.65

Table 6 Factors associated with identifying ≥4 PVAs by Multivariable Logistic Legression Analysis.

Variable	**COR**	**95 CI**	**P value**
Year of residency	4.2	1.15-15.23	0.03
Presenting or attending seminar on MV waveforms	13.05	1.54-110.5	0.037
Teaching hospital	7.72	2.33-25.6	0.001
Training on MV	0.8	0.21-3.23	0.7
Attending Lectures on MV	0.5	0.09-2.8	0.4

6. DISCUSSION

The main findings of our study were poor competency of EMCC residents to identify PVAs by waveform analysis and being presenters or attendees of seminars on MV waveforms, higher years of residency, and being TASH resident were associated with correct identification of PVAs by analyzing MV waveforms. It is lower, when compared to studies done in 20 countries in Europe, South America and USA focused on ICU health professionals (respiratory therapists, physicians and nurses) where 56.8% of them identified 4 PVAs. In addition, only one resident was able to identify all PVA (1.3%), when compared to the mentioned study done on 20 countries (19.5%) (out of 6 PVAs), 21.3% in Chilean study and 10.2% in Saudi study (out of 3 PVAs) This difference might be explained by variation in sample size, study methods, degree of training ,health care system set up, and unlike our study, their studies were done on qualified health care professionals.

Considering PVA is common and its clinical consequences, and EMCC residents have key role assuring patient ventilator interaction, and their incompetency on identifying PVAs may affect patient's clinical outcome adversely.

This study revealed a notable correlation between competencies of EMCC residents in recognizing PVAs participation in seminars on MV waveforms. This is in consistent with a previous study done on critical care fellows, which concluded that conventional fellowship training might not adequately equip individuals with the skills to analyze mechanical ventilator waveforms. Therefore, implementing a purposeful and well-structured course on MV could assist fellowship programs in achieving their educational objectives regarding MV (14) additionally majority of residents who couldn't identify any PVA on waveforms didn't participate in seminars on MV waveforms, which allies with Bahmed F et al. study which shows seminar help to improve medical students knowledge and self-learning on a particular subject (21).

Another factor associated was year's residency as expected clinical skills with the knowledge base acquired expected to increase as year's residency increases. Another unexpected finding was competency difference in teaching hospitals, with possible reasons of trend of seminar presentation on waveforms during PICU, and Zewditu hospital's ICUs in TASH EMCC residents.

Our study findings are in contrary with Ramirez et. Al. studies that those ICU healthcare professionals with training on MV , working in specific ICU (SICU and CICU) increase their identifying competency of PVAS by analyzing MV waveforms(13). The possible explanation could be different characteristics of training (training courses >100 hrs. completed were associated with correct identification of PVAs in Ramirez et al studies) and diminished emphasis on MV waveforms and PVA in the content of training manuals. Our findings are consistent with Ramirez et al. studies that age, experience of working at ICU, greater number of ICU rotation didn't shown associated with competency of residents to identify PVA bBy analyzing MV waveforms (13).

This study has the following limitations. First; residents were assessed by online link out of clinical context which is prone to response bias, add had unlimited time to answer. Second, they could use materials to answer questions. Third, the used waveforms were not breath by breath analysis. Additionally, the assessment toll didn't incorporate reverse triggering as one of the PVAs under investigation due to its challenging nature. Reverse triggering is ruled out from waveforms because of difficulty of identifying it by pressure time and flow time scalars. Overshooting was nulled as well due to low level of agreement by experts. Fifth, one resident may respond with different telegram accounts and there is possibility of guessing answers since waveforms tests were multiple choice questions. The other limitation was it did not include EMCC residents in other places in Ethiopia and anesthesia residents and Level of agreement should have been done by participating consultants too.

7. CONCLUSION

Common patient ventilator asynchrony identification by using mechanical ventilator waveforms was found low among EMCC residents. Our study found that there is significant relationship between EMCC resident's competency to identify PVAs, and presenting or attending seminars on MV waveforms and their identifying ability increases with years of residency.

8. RECOMMENDATIONS

We recommend enhancing seminars on waveforms and PVAs as one way of educational approach rather than only sticking to the routine method of didactic lecture process to promote self-learning.

We recommend respective bodies to give emphasis to MV waveforms on curriculum/ICU protocols

Future research is recommended to assess association between proper identification and management of patient ventilator asynchrony.

9. REFERENCE

1. Bulleri E, Fusi C, Bambi S, Pisani L. Patient-ventilator asynchronies: types, outcomes and nursing detection skills. Acta Biomed. 2018;89(7-s):6-18.
2. Kirby RR. Improving ventilator-patient interaction: reduction of flow dyssynchrony. Crit Care Med. 1997;25(10):1630.
3. Epstein SK. How often does patient-ventilator asynchrony occur and what are the consequences? Respiratory care. 2011;56(1):25-38.
4. Gilstrap D, MacIntyre N. Patient-ventilator interactions. Implications for clinical management. Am J Respir Crit Care Med. 2013;188(9):1058-68.
5. Zhou Y, Holets SR, Li M, Cortes-Puentes GA, Meyer TJ, Hanson AC, et al. Etiology, incidence, and outcomes of patient-ventilator asynchrony in critically-ill patients undergoing invasive mechanical ventilation. Sci Rep. 2021;11(1):12390.
6. Goligher EC, Brochard LJ, Reid WD, Fan E, Saarela O, Slutsky AS, et al. Diaphragmatic myotrauma: a mediator of prolonged ventilation and poor patient outcomes in acute respiratory failure. Lancet Respir Med. 2019;7(1):90-8.
7. Thille AW, Rodriguez P, Cabello B, Lellouche F, Brochard L. Patient-ventilator asynchrony during assisted mechanical ventilation. Intensive Care Med. 2006;32(10):1515-22.
8. Garofalo E, Bruni A, Pelaia C, Liparota L, Lombardo N, Longhini F, et al. Recognizing, quantifying and managing patient-ventilator asynchrony in invasive and noninvasive ventilation. Expert Rev Respir Med. 2018;12(7):557-67.
9. Murias G, Lucangelo U, Blanch L. Patient-ventilator asynchrony. Curr Opin Crit Care. 2016;22(1):53-9.
10. Dexter AM, Clark K. Ventilator Graphics: Scalars, Loops, & Secondary Measures. Respir Care. 2020;65(6):739-59.
11. Alqahtani JS, AlAhmari MD, Alshamrani KH, Alshehri AM, Althumayri MA, Ghazwani AA, et al. Patient-Ventilator Asynchrony in Critical Care Settings: National Outcomes of Ventilator Waveform Analysis. Heart Lung. 2020;49(5):630-6.
12. Ramirez II, Arellano DH, Adasme RS, Landeros JM, Salinas FA, Vargas AG, et al. Ability of ICU health-care professionals to identify patient-ventilator asynchrony using waveform analysis. Respiratory care. 2017;62(2):144-9.
13. Ramírez, II, Adasme RS, Arellano DH, Rocha ARM, Andrade FMD, Núñez-Silveira J, et al. Identifying and managing patient-ventilator asynchrony: An international survey. Med Intensiva (Engl Ed). 2021;45(3):138-46.
14. Seam N, Kriner E, Woods CJ, Shah NG, Acho M, McCurdy MT, et al. Impact of Novel Multiinstitutional Curriculum on Critical Care Fellow Ventilator Knowledge. ATS Sch. 2020;2(1):84-96.
15. Seam N, Kriner E, Woods CJ, Shah NG, Acho M, McCurdy MT, et al. Impact of novel multiinstitutional curriculum on critical care fellow ventilator knowledge. ATS scholar. 2021;2(1):84-96.
16. Abdelgawad ME. Critical care nurses' knowledge and attitudes

toward using ventilator waveform monitoring to

detect patient-ventilator asynchrony: A crosssectional online survey. research square. 2022.
17. [Available from: www.aau.edu.et/admision/academics/grading-system/.
18. Lynch-Smith D, Thompson CL, Pickering RG, Wan JY. Education on Patient-Ventilator Synchrony, Clinicians' Knowledge Level, and Duration of Mechanical Ventilation. Am J Crit Care. 2016;25(6):545-51.
19. Eric Kriner B, RRT. Patient-Ventilator Dysynchrony

in CMV-Volume https://www.ncsrc.org/: MedStar Washington Hospital Center; 2014 [updated 2019. Available from: https://www.ncsrc.org/wp-content/uploads/2014/08/Patient-Ventilator-Dysynchrony-in-CMV-Volume-Kriner1.pdf.
20. Holanda MA. Auto PEEP from ICU Monte Klinikum Hospital Fortaleza, Brazil 2020 [Available from: https://xlung.net/en/quizzes/46.
21. F B. Impact of seminars by and for medical students Researchgate2014 [Available from: https://www.researchgate.net/publication/262103394_Impact_of_seminars_by_and_for_medical_students.

10. ANNEXES

Annex 1: information and consent form

Dear Participant,

My name is Dr. Wegderes Bogale and I am a 3rd year Emergency Medicine & Critical Care resident. I am currently doing my research on "Assessment of emergency medicine and Critical care resident's competency of identifying Patient Ventilator asynchrony using ventilator Waveform Analysis in Addis Ababa, Ethiopia". Aim of this research is to explore EMCC residents' competency and associated factors to identify Patient ventilator asynchrony (PVA) by using mechanical ventilator (MV) waveforms.

This questionnaire was designed to collect data regarding your experience on MV waveforms to identify PVA and it is strictly for academic purposes. To researchers knowledge this will be the first research on this area in our country and will have implications on patients care on MV, given that PVA is common. The information gathered will solely be utilized for the objectives of this research. Confidentiality will be ensured. Your involvement will greatly contribute to expanding the existing knowledge in this field, making it crucial for the study's success. However, your participation is entirely optional, and you are free to decline at any stage if you wish to do so. Thank you in advance.

Please use the following contact information in case you have questions.

Respectfully,

Dr. Wegderes Bogale

+251 -915570262

E-mail; wegbogale62@gmail.com

Annex 2: Consent form

I declare that the purpose, procedure as well as consequences of participation have been explained to me and I have understood .I hereby agree to take part in the study

Annex 3: Questionnaires (11-13, 19)

Directions: please select the best choices for multiple choice answers and write comments to given space thank you!

1. Age in number ________

2. Sex A) Male B) Female

3. Which teaching hospital are you in A.TASH B.SPHMMC

4. Your of residency A) 2nd b) 3rd

5. Year of experience in medical practice? A. <5 B.>5

6. Have you completed either on-line or in-person training on MV from a formal institution which includes, PVA, and MV waveforms analysis among the topic? .A. yes B.no

   If yes for Q 6, estimated number hrs. Dedicated for training

7. Did you have any MV lectures in your residency stay? A(YES B)NO

   If yes for Q 7 , did you attend all classes? A. Yes B. No

   If yes was patient ventilator asynchrony included? A. yes B.no

   If yes, was MV waveforms added among the added to lectures? A. yes B.no

8. Number of rotation (in months) of ICU you have worked at each ICU (MICU SICU, PICU, and CCU?)______

9. Did you ever have bedside teaching and simulations on MV waveforms during you ICU attachment? A) YES B) NO

If yes for Q.9. With whom do you have these activities frequently? A) Senior resident B) EMCC consultant C) intesivist D) Pulmonologist E) Anesthesiologist

If yes to q 9 how do you rate these activities?

A. substantial change is needed

B. adequate with some change needed

C. very helpful, no change needed

D. Outstanding.

10. How confident are you on identifying asynchrony by using MV waveforms?

A. very confident

B. somehow confident

C. Neutral

D. unconfident

11. Have you presented or attended seminars on MV waveforms a)yes b)no

12 number of rotation to ICU in numbers

14 to which ICU did you have greater number of rotation A)MICU B)SICU C)CICU D)NICU E)PICU

Part 2-waveform tests

Each case below, please CIRCLE ALL descriptions that apply to the wave form. (CHOOSE ALL THAT APPLY)

A. I really have no idea for this case

B. Normal Wave Forms

C. Auto peep

D. Ineffective triggering

E. Auto triggering

F. double triggering

G. Delayed Cycling

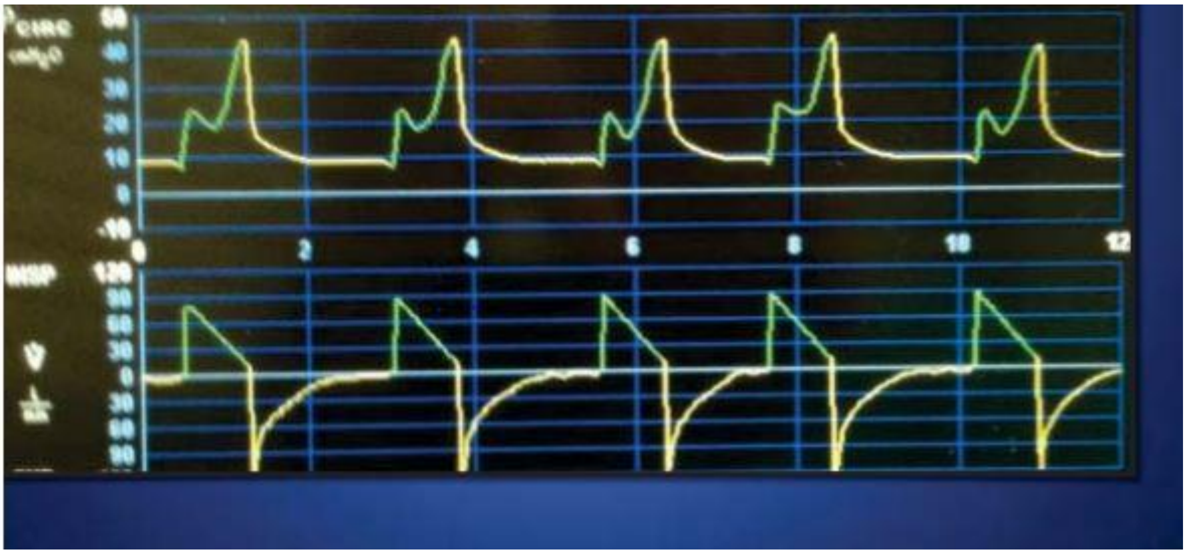
h. Flow Starvation

I. overshooting

J .revers triggering

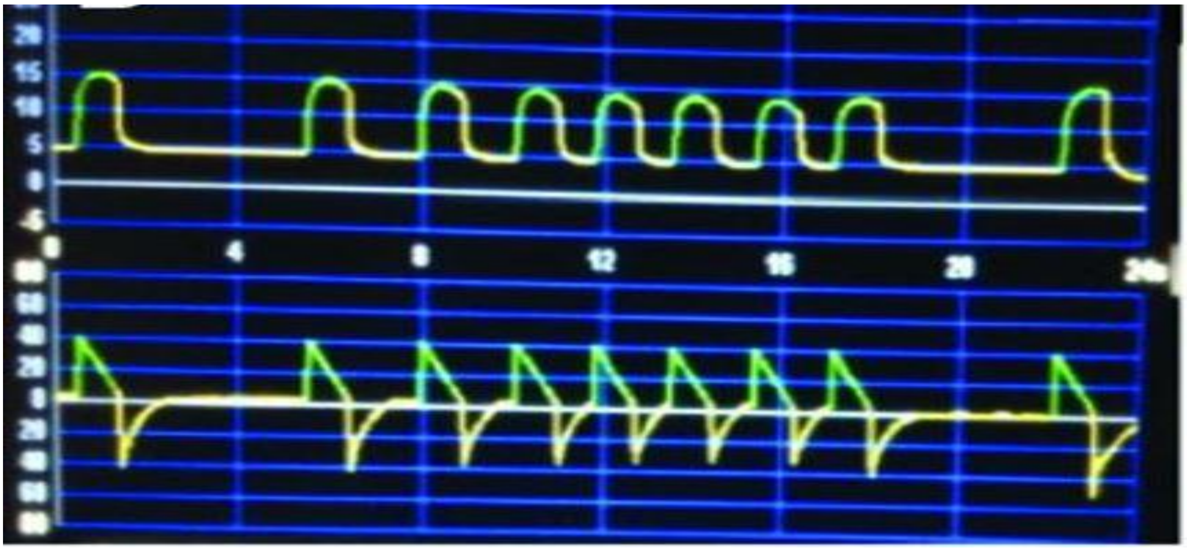
L. Peak pressure apnea

Flow starvation(19)

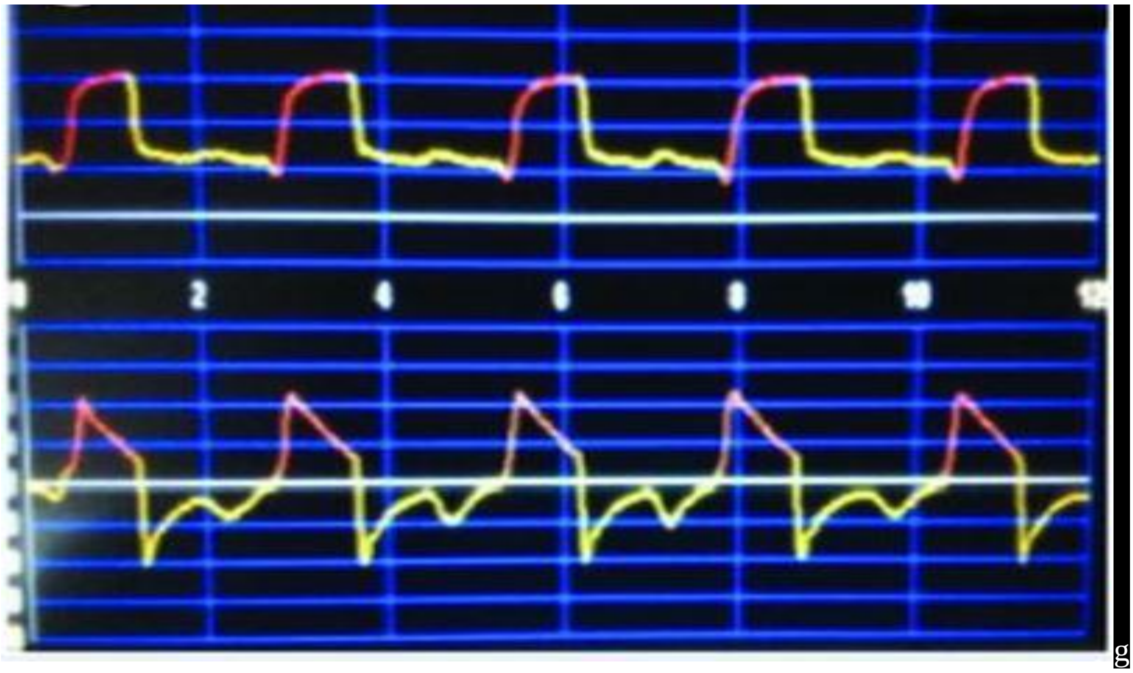


Premature cycling (19).

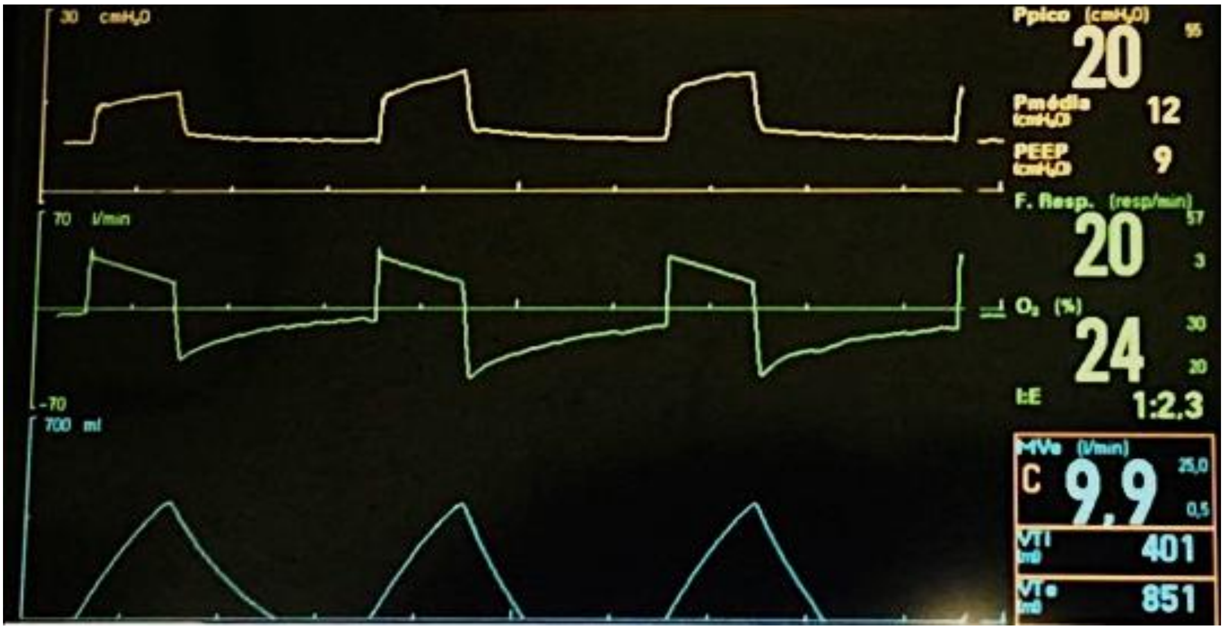
Auto triggering (12)



Ineffective triggering (12)



AutoPEEP([20])



Delayed cycling([19])

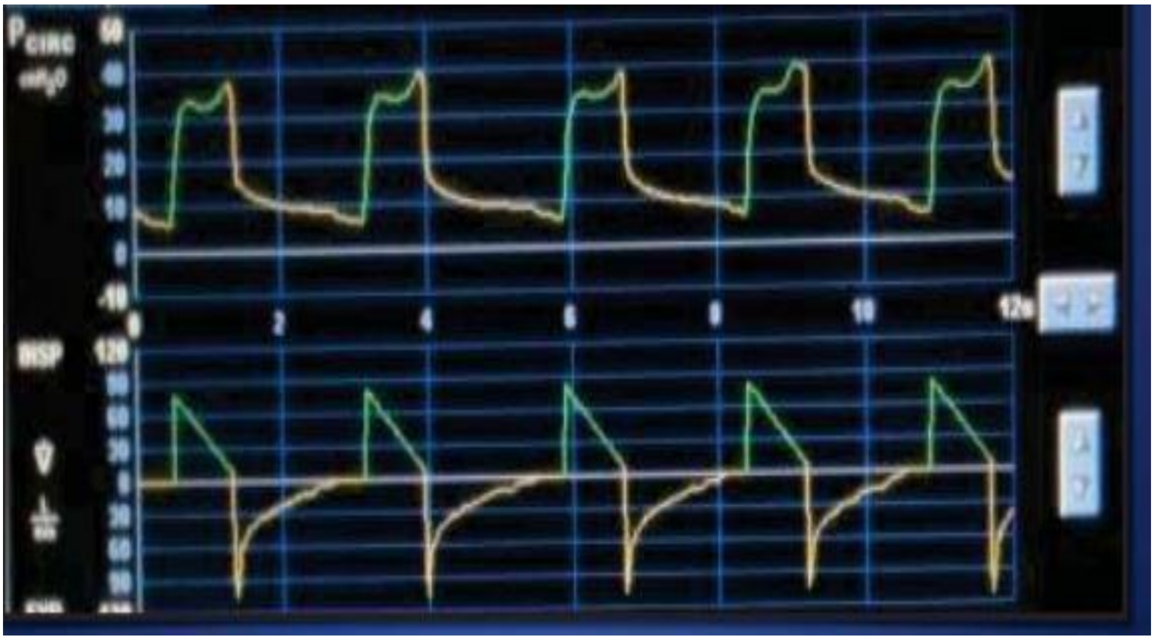


Figure 4 approval letter to collect data

ADDIS ABABA UNIVERSITY
School of Medicine
Dept. Emergency Medicine

አዲስ አበባ ዩኒቨርሲቲ
ሕክምና ትምህርት ቤት
የድንገተኛ ሕክምና ትምህርት ክፍል

Date: 22 - August - 2023

Ref No: EM/551 / 2015

To Whom It May Concern

Subject: Ethical Clearance

Dr. Wegderes Bogale is Emergency and Critical Care Final Year Resident in our Department of Emergency Medicine. The student is conducting thesis research entitled "emergency medicine and critical care residents' competency to identify patient ventilator asynchrony using mechanical ventilator waveforms Analysis in Addis Ababa, Ethiopia. "

The proposal has been submitted to the Department Research Ethics Review Committee and got approval from the committee. Thus, the department requests your very kind cooperation in data collection.

With best regards,

Dr.Temesgen Beyene (MD, ECCM, MPH)

Associate Professor of Emergency Medicine

Chair, Department of Emergency Medicine

SOM, Tikur Anbessa Specialized Hospital (TASH)

College of Health Sciences, Addis Ababa University

DECLARATION

I, declare this thesis is my work and all quoted materials are referenced

Name: Dr. Wegderes Bogale Sig:_________ date__________

This is to certify the thesis with title “assessment of emergency medicine and Critical care resident’s competency to identify Patient Ventilator asynchrony using mechanical ventilator Waveforms Analysis in Addis Ababa, Ethiopia” by Dr. Wegderes Bogale for partial fulfillment of requirement for the certificate of specialty in Emergency Medicine and Critical Care complies with the regulations of the university and was conducted with the criteria for originality and equality by Dr. Merahi Kefyalew. (MD, assistant professor of EMCC)

Advisors Name

Dr. Merahi Kefyalew Sig_______ date_______

Examiners name

External:____________ Sig __________date _____/____/_____

Internal: _____________________ Sig __________date ____/____/______