Adequacy of EMS systems of care protocols for adults with OHCA, STEMI & Stroke in Oregon: a structured review

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Disclosure:

The author is the medical director and supervising physician for the ambulance agencies in Jackson County. This project is supported by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services (HHS) under grant number H54RH00049, Rural Hospital Flexibility Program. This information or content and conclusions are those of the author and should not be construed as the official position or policy of, nor should any endorsements be inferred by HRSA, HHS or the U.S. Government.

Title

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Running Title

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Key words

STEMI, Stroke, OHCA, Systems of Care, Emergency Medical Services (EMS), Variability, Clinical Practice Variations

Abstract

Background

Out of hospital Cardiac Arrest (OHCA), ST-segment Elevation Myocardial Infarction (STEMI) and stroke are 3 commonly encountered prehospital conditions for which systems of care have been developed to improve adult patient outcomes. Several published evidence-based guidelines suggest best practices for EMS treatment protocols for these conditions.

Objective

To examine the adequacy in Oregon ambulance protocols for OHCA, STEMI & stroke systems of care in Oregon.

Methods

Oregon ambulance treatment protocols for OHCA, STEMI and stroke received were reviewed in a structured fashion. Treatment protocols elements were abstracted and analyzed. Descriptive statistics and chi-square were used to summarize the findings.

Results

Protocols were received from 95 Oregon ambulance agencies from 34 of Oregon's 36 counties. There were 31 different protocols used in the 60 Rural agencies and 9 different protocols used in the 35 Non-rural agencies. At least 75% of the protocols were dated within the prior 4 years; more so in protocols from Non-rural agencies compared to Rural agencies. Evidence-based guideline elements were mentioned or followed variably ranging from 0-100% of the time. In general, elements from Non-rural agencies were mentioned or specified more often than those from the Rural agencies. The most common elements missing from the protocols were specific event times and tidal volumes for ventilations.

Conclusions

In Oregon, EMS protocols for OHCA, STEMI or stroke systems of care were quite varied. Of the evidence-based guideline elements, two were found in all protocols for OHCA, four in all protocols for STEMI, and one in all protocols for stroke. All the guideline recommendations for stroke were included in protocols from 3 agencies; no protocols for OHCA or STEMI included all the recommended elements.

Introduction

The purpose of this study was to examine the adequacy of EMS protocols for adult patients with Out of Hospital Cardiac Arrest (OHCA), STEMI (ST Elevation Myocardial Infarction) and stroke for ambulance agencies throughout the State of Oregon. The study was to determine the number of EMS protocols from rural ambulance agencies, which met all the evidence-based guidelines and which met selected evidence-guided or best practices in each of these 3 systems of care. A tool kit of model protocols using evidence-based best practices was developed for these three systems of care that might be beneficial across the state (Appendix A).

Methods

Study Design

Cross-sectional review of current ambulance EMS protocols for adults for OHCA, STEMI and stroke systems of care in the State of Oregon.

Study Population and Setting

EMS protocols were collected from Oregon ambulance agencies, which provided service in one or more Ambulance Service Areas (ASAs). Copies of the EMS protocols were received from the EMS agency or downloaded from the EMS agency website.

Variables and Data Collection

Protocols were reviewed by the author in a structured format using a standardized data collection tool for abstracted data elements (Table 1, 2, 3), which had been piloted and refined after the first 10 protocols. Evidence-guided elements or best practices (marked with an *) were defined as those listed in the appropriate NASEMSO Model EMS Clinical Guidelines[1] or American Heart Association (AHA) Guidelines[2,3,4,5,6,7,8]. A few additional elements were added by the author based on his EMS medical direction education, experience and clinical judgment.

Statistical Analysis

Descriptive statistics, chi-square and z-test were used to characterize findings.

Research ethics review

This study was reviewed and determined by the Oregon Health & Science University to be research not involving human subjects

Results

Ambulance service in Oregon is provided by a licensed ambulance provider in each county-managed Ambulance Service Area (ASA)[9] (Fig. 1). Air ambulance service is not governed by this ASA process. According to the State of Oregon EMS & Trauma Office there are 140 licensed ambulance agencies in Oregon, of which 9 provide only air ambulance service and another 10 have a licensed ambulance, but are not an ambulance provider in an ASA. EMS protocols for adults with OHCA, STEMI and stroke were received from 95 of the 121 Oregon ground ambulance agencies, which provide service in one or more Oregon ASAs. Of the 95 EMS agencies from which protocols were received, 60 (63%) were located in counties considered to be Rural or Frontier by the Oregon Office of Rural Health and designated Rural for the purposes of this study; the other 35 (37%) counties were designated Non-rural. There were 38 distinct sets of protocols received, as several regions have developed protocols covering multiple agencies (range 1-10) in a region, a county, part of a county, or group of counties. The 60 Rural counties had 31 separate protocol sets and the 35 Non-rural counties had 9 separate protocol sets.

Protocols were obtained from EMS agencies in 34 of the 36 Oregon counties (Fig. 2). The number of protocols obtained per county ranged from 1-10. At least 75% of all the protocols were dated within the prior 4 years (Table 4). At least 97% of the protocols from the Non-rural agencies had an effective date within the prior 4 years. A smaller percentage (77-84%) from Rural agencies had an effective date within the prior 4 years. Almost one tenth of the protocols received from the Rural EMS agencies did not list a date, compared with none of those from Non-rural agencies.

Data element presence ranged from 0% to 100% in protocols for OHCA (Tables 5 & 6), STEMI (Table 7) and stroke (Table 8). All OHCA protocols mentioned initial vasopressor and initial advanced airway. All STEMI protocols required a 12 lead ECG, noted the establishment of intravenous access, and mentioned the administration of nitroglycerin (NTG) and an analgesic. All stroke protocols specified time of onset of symptoms. None of the OHCA protocols required Code 3 (lights & siren) transport. None of the STEMI or stroke protocols noted EMS fibrinolytic administration. None of the stroke protocols required the EMS provider to obtain Online Medical Control (OLMC). Protocols from 3 agencies contained all the evidence-based guideline elements for stroke (Table 9). Two of these were from Rural agencies using the same protocols and one was a Non-rural agency. None of the protocols for OHCA or STEMI contained all the evidence-based

guideline elements. In general, the protocols from the Non-rural agencies were more likely to mention a data element than were those from Rural agencies. Three Rural agencies supplied protocols for OHCA and STEMI, but not for stroke. Variation was noted in individual data elements for protocols for all 3 systems of care.

OHCA evidence-based guideline elements were noted quite variably ranging from initial vasopressor and initial advanced airway in all protocols to Time CPR Started in less than 10%. Epinephrine was listed as the initial vasopressor in 60% of the protocols and either epinephrine or vasopressin in 40%. A variety of initial advanced airways were listed including endotracheal tube, supraglottic airway, King airway, LMA, pharyngeal esophageal airway device, CombiTube, dual lumen airway device, blind insertion device and cuffed pharyngeal airway device. The initial anti-arrhythmic listed was usually amiodarone (in 82% of the protocols) and less likely lidocaine (in 12%) or either (in 4%). Early AED/defibrillator use was noted, often with the caveat of after 1-2 minutes of CPR if the downtime was more than 5 minutes or if the arrest was unwitnessed (Table 6). Defibrillation energy was variably noted as specific to one device or per manufacturer's recommendation. Monophasic defibrillation was mentioned infrequently. Most protocols listed escalating defibrillation energies. Some protocols noted double sequential defibrillation for ventricular fibrillation unresponsive to ongoing CPR, standard defibrillation, vasopressor and antiarrhythmic administration. Most of the protocols specified a chest compression rate of 100 per minute or more as recommended in the guidelines. Chest compression depth was usually listed as at least 2 inches or 2-2.4 inches, although one protocol listed a depth of 1.5-2 inches. Ventilation rates were noted in more than half the protocols and split between a specific rate and a ratio with chest compressions. Interrupted chest compressions were specified slightly more often than continuous chest compressions. Defibrillator download for post-event review of resuscitation was specified in only 4 protocols. Rapid determination of cardiac arrest was specified in less than one third of the EMS protocols, although this is really a 911 dispatch process. Only about one in ten protocols mentioned mechanical CPR.

If ROSC was obtained following OHCA, 12 lead ECG analysis was specified in about half the protocols. Cooling by EMS with ice packs or iced saline IV was noted in about half the protocols, more often in Non-rural protocols than in Rural protocols. Less than half the protocols noted hospital bypass for patients with ROSC. A few protocols called for specific hospital ROSC notification with the term "Cooling Activation".

For STEMI protocols, IV established was noted in all, including details such as saline lock unless IV fluid or medication was needed, 2 or even 3 IVs if a STEMI was present, and to avoid the right wrist if possible. Hospital bypass and notification were required in 77% or more, using terms including “STEMI Activation”, “STEMI Alert”, “Cath Alert”, “STEMI patient”, “Code Heart”, Heart One” or “AMI”. Paramedic reading or auto-analysis for 12 lead ECG interpretation was included in three-quarters of the protocols and paramedic reading only in about 10%. All the protocols detailed nitroglycerin administration, with a minimum systolic blood pressure limit of 100 mm Hg twice as often as 90 mm Hg. Likewise, analgesic administration was detailed in all, usually with morphine, slightly more often than with fentanyl, and infrequently with nalbuphine, meperidine or hydromorphone. About half the protocols noted 12 lead ECG transmission, often with the caveat of “if available” and sometimes for “non-paramedic”. Less than half the protocols had an upper age limit for STEMI activation, which included 85, 86 and 90 years. Specific event times were mentioned in less than half the protocols. Code 3 transport for STEMI patients was required infrequently.

All of the EMS protocols for stroke specified a time of onset (hours since last seen normal) which ranged from 2 to 6 hours, most commonly 3, 4.5 or 6 hours. Almost all (97% or more) specified hypoglycemia treatment, establishment of an IV, use of a stroke evaluation method and blood glucose determination. Elevation of the head of the stroke patient’s bed (ranging from 0-30°) during transport was noted in more than half the protocols. About half the protocols noted hospital bypass, obtaining a 12 lead ECG and hospital notification using the terms “Stroke Alert”, Stroke One”, “Stroke Activation” or ”Stroke Team Alert”. Code 3 transport for stroke patients was required in less than one third of the protocols.

During the review comments were noted in some protocols, which were not analyzed further (Table 10).

Discussion

Most of the Oregon EMS protocols received and reviewed noted many of the evidence-based guidelines or best practices for OHCA, STEMI or stroke. The most common elements lacking from the protocols were specific event times and tidal volumes for ventilations. Some of the guidelines are fairly explicit such as a CPR chest compression rate of 100-120 per minute or a 12 lead ECG for all patients with a possible STEMI. Other guidelines are less specific, allowing for variation depending on the local situation, such as interrupted or continuous CPR chest compressions, the use of mechanical CPR, the aspirin dose for STEMI, or the time threshold of 3, 4.5, or 6 hours for acute stroke intervention. Hospital bypass specifications were not usually detailed in the protocols and may be very dependent on local and time-dependent conditions such as geography, ambulance agency resources, weather, or available aircraft.

Oregon model guidelines were developed for each system of care: OHCA - High Performance CPR & VF/VT, STEMI and stroke (Appendix A) based primarily on published guidelines and also on the author's best professional judgment. As noted above, the guidelines sometimes noted options and these items are shown in *italics* in the model protocols. Some protocol items may be very system-specific and were not further delineated, such as the number of IV sites for patients with STEMI or stroke or the specific destination hospital for patients with STEMI or stroke. None of the protocols examined specified fibrinolytics for patients with STEMI or stroke so this modality was omitted from the model protocols.

Although not a purpose of this project, during the protocol abstraction process a number of observations were made about the protocols themselves. Many of the protocols appeared very similar to others, suggesting that protocols may be shared amongst agencies, some of which are quite geographically distant from each other. Protocols appeared to be organized in outline form, as flow charts, or, infrequently, as narratives. Most of the protocols obtained were searchable: for .pdf files using Acrobat Reader (Adobe Acrobat Reader DC, Version 2015.010.20059) or for .doc or .rtf files using WORD (Microsoft® Word for Mac 2011, Version 14.5.9), suggesting that they were generated directly from computer software. A few of the protocols were not searchable with the software or had misaligned text or image artifacts suggesting hole punches, indicating that these were paper versions which had subsequently been scanned before being emailed to the investigator.

EMS protocols in the United States have been described as individual (as is the case in Oregon), regional, model statewide or mandatory statewide[10]. Where generally agreed upon EMS guidelines exist, such as to a large degree for OHCA, STEMI and stroke, an argument can be made that EMS protocols should be established statewide or at least regionally, based upon the institution(s) likely to receive patients transported by EMS. The capabilities of the receiving institutions may vary significantly. Especially in the more rural parts of Oregon, options for long-distance air ambulance transport may be limited by weather conditions and the available aircraft. The Oregon trauma system[11] with its State Trauma Advisory Board (STAB) and Area Trauma Advisory Boards (ATABs) could provide a model for the further development of these other time sensitive systems of care.

EMS agency medical direction in Oregon is provided by physicians on a part-time basis in addition to their other responsibilities, who provide EMS medical direction ranging from about half-time to a few hours per month or even less. The larger number of older or undated protocols from Rural agencies suggests that these EMS medical directors may have less time and energy to spend on EMS protocols. The creation and review of EMS protocols may be an easier task in many ways when a number of medical directors work together in a geographic region, as opposed to the very part-time medical director who works in a distant part of the state and has limited contact with nearby peers.

The development of regional EMS protocols may enhance safety by reducing variability, which has been associated with fewer errors[12]. Error reduction in medicine[13] and in EMS[14] in particular have been national topics of concern for a number of years. Variability has been noted in other studies that have looked at statewide EMS protocols[9], as well as EMS protocols for naloxone administration[15], pelvic binding[16], blood glucose measurement in seizure patients which was associated with delayed seizure treatment[17], and hypoglycemia treatment[18]. EMS providers may work in a number of different agencies or move to a different area and encounter protocol differences that may not always be recognized in a timely fashion in the dynamic prehospital work environment. If there is no physiologic or scientific basis for these differences, protocol standardization may result in fewer errors and enhance patient safety. The frequently heard adage “If you’ve seen one EMS system, then you’ve seen one EMS system” applies to EMS protocols as well. As the body of prehospital and EMS knowledge and research expands, the spread of evidence-based guidelines in the

development of EMS protocols to improve patient care, as has been promulgated[19], is worthy of further consideration in Oregon.

Limitations

Limitations to this survey include missing protocols, the denominator chosen, the point-in-time survey, and challenges of data abstraction.

EMS protocols were requested by the Oregon Health Authority's EMS & Trauma Office from Oregon ambulance agencies providing emergency patient transportation in one of the ASAs. Most were sent by the EMS agency and some were found posted on the agency's website. Protocols from some agencies were not received despite multiple requests. The State of Oregon was not able to provide a list of ASAs and the assigned ambulance agencies so it is possible that some ambulance agencies providing patient transport in an ASA were missed or that a few non-ASA ambulance agencies were included, particularly if the ASA assignee subcontracts with a different ambulance agency or if there is more than one ambulance provider in an ASA. More than one protocol was received from some agencies, sometimes with different effective dates suggesting the possibility of different protocol details. Some of the protocols were in the process of being updated and may have changed between the time of review and the time this report was completed.

The denominator used in this study was ambulance agencies, not separate protocols. Non-rural agencies had an average of 0.26 protocols/agency compared to 0.52 protocols/agency for Rural agencies, which is significantly different (z test $p = 0.0134$). Use of agencies as the denominator emphasizes the effect of the relatively large proportion of common protocols in Non-rural agencies compared to Rural agencies.

Protocols reviewed noted a variety of effective dates and some with no date at all. Some of the protocols were received with a note that the protocols were in the process of being revised. Updated evidence-based guidelines are published every few years as new science is learned and put into practice. Research and updating of EMS protocols is a time-consuming process that EMS medical directors do periodically, every year to few years, so that the findings of this study would likely be different from a similar review if done at a future date.

Data elements were abstracted from EMS protocols to determine positive (Yes) answers or negative (Not listed) answers. Negative answers could mean either that the element was not present or could not be located. Some EMS agencies sent their entire set of protocols, others sent only a limited set. Most of the data elements for STEMI were abstracted from cardiac chest pain or STEMI protocols, for stroke from stroke

or CVA protocols, and for OHCA from cardiac arrest or ventricular fibrillation protocols. Some elements were not listed in any of these protocols and other protocols, if available, were searched for details of CPR, termination of resuscitation (TOR), destination, morphine, nitroglycerin (NTG), oxygen, aspirin, magnesium, airway management or universal patient care. Specific event time and ventilation tidal volume were the least frequently note data elements which may have been listed in different places in the protocols or "assumed" to be basic EMS provider care and not mentioned at all. Some of the guideline elements allowed for options or were not always clearly specified so the author used his experience and professional judgment to interpret some of the guideline elements or best practices. Other experienced reviewers might make slightly different choices for some of these elements.

Finally, this study reviewed written EMS protocols, which may differ from what actually occurs during prehospital care.

Conclusion

In Oregon, EMS adult protocols for OHCA, STEMI or stroke systems of care were quite varied. Two of the evidence-based guideline elements were noted in all OHCA protocols, four in all STEMI protocols and one in all stroke protocols. Three agencies, using 2 different sets of protocols, listed all the stroke evidence-based guideline elements. Some elements were mentioned frequently and still others rather infrequently. Specific event times and tidal volumes were detailed least often. Further study may help determine the minimum set of evidence-based guideline elements, which should be included in each of the protocols for OHCA, STEMI and stroke. Processes can then be developed to insure that all EMS protocols contain the essential elements for each system of care.

Acknowledgements

Ken Kempner, PhD and Meredith Guardino for editorial review.

Figure 1. Map of Oregon Ambulance Service Areas (ASAs) and ASA holders - 2008

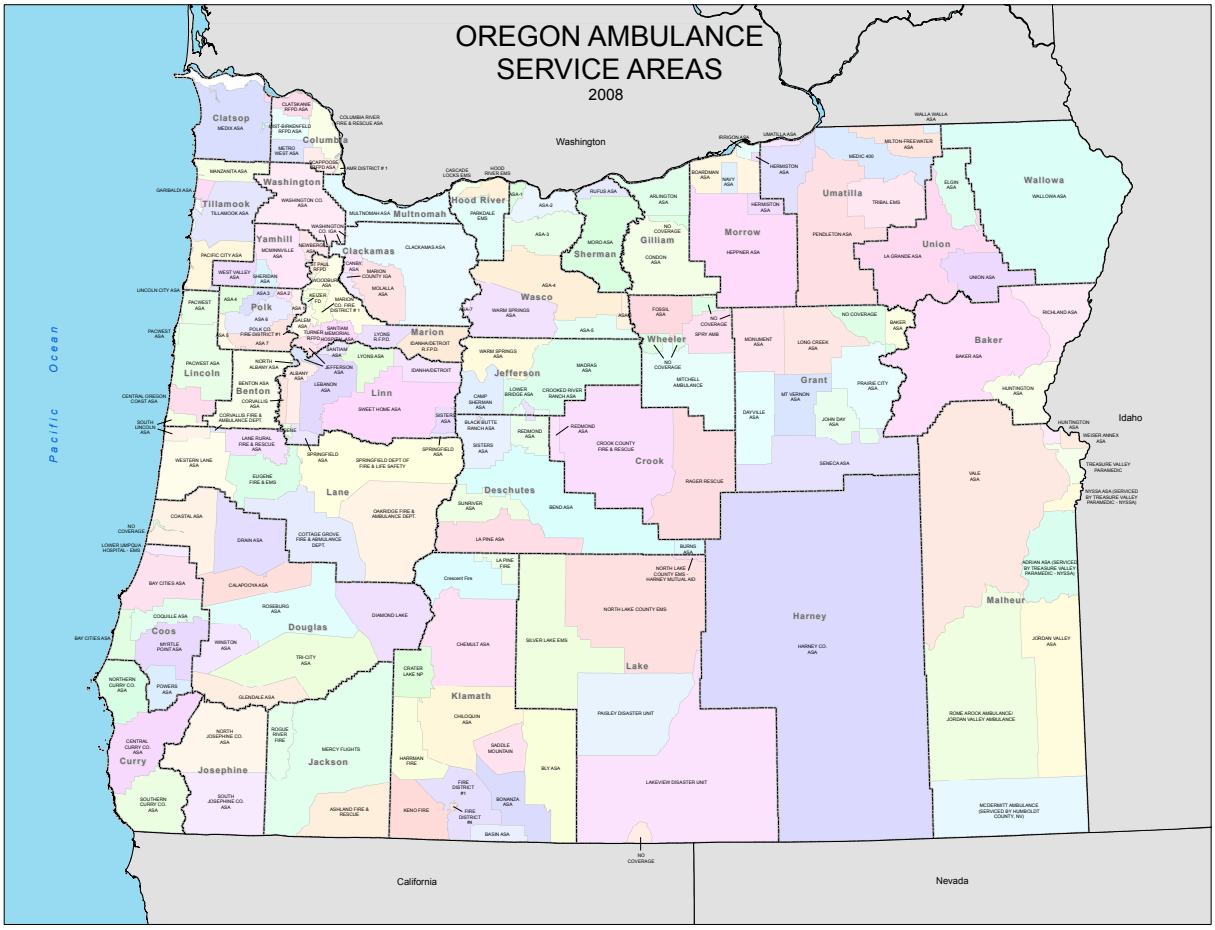
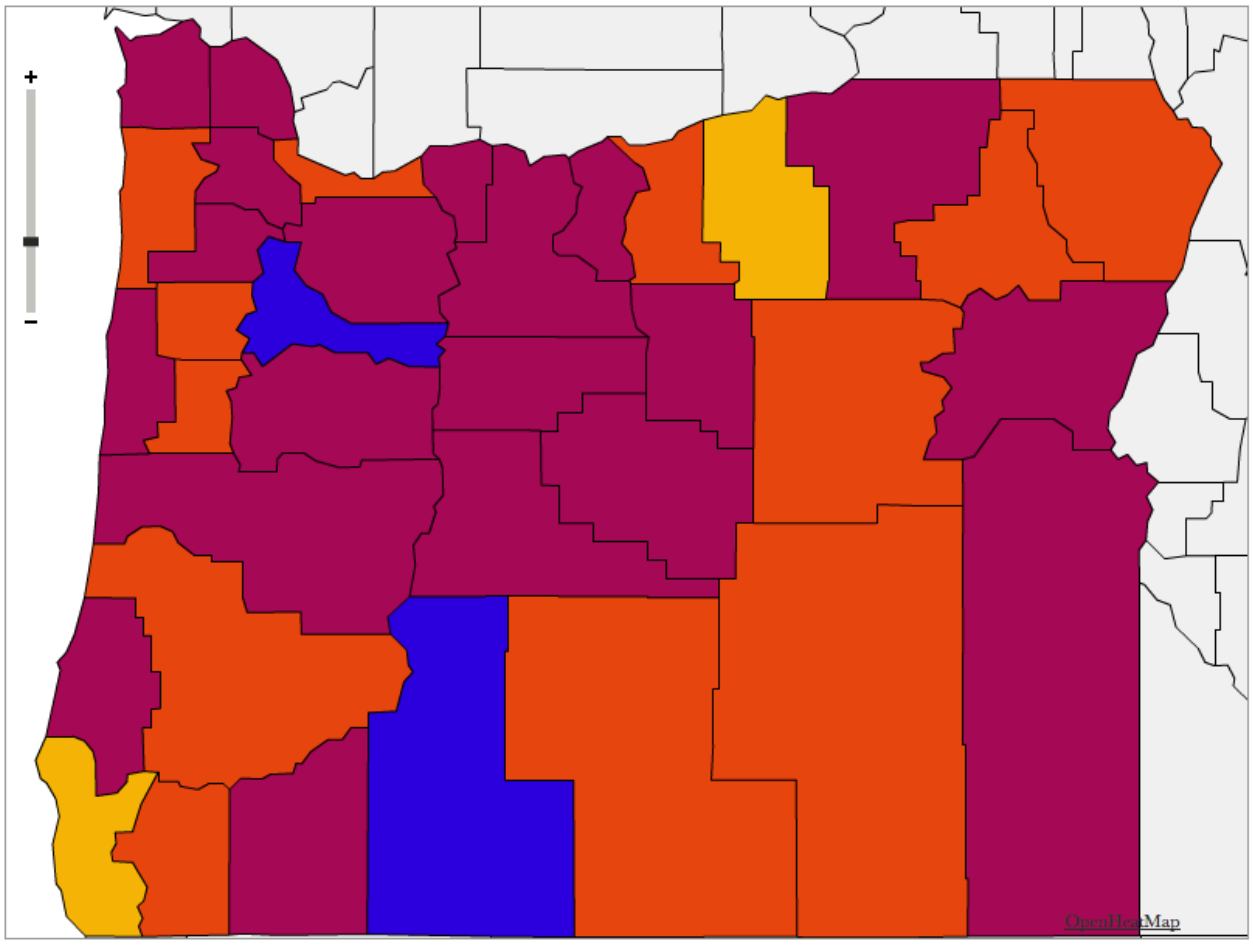


Figure 2. Map of Oregon counties showing the number of EMS agencies from which protocols were received



No protocols received	1 EMS agency	2-5 EMS agencies	6-10 EMS agencies

Table 1. Out of Hospital Cardiac Arrest (OHCA) EMS protocol data elements

Data element	NASEMSO[1]	AHA ECC 2015 BLS[3]	AHA ECC 2015 ALS[4]
Protocol effective date			
*Rapid determination of cardiac arrest (Location, Unconscious, Abnormal breathing, Initiate CPR)		X	
*Initial cardiac rhythm	X		
Time of cardiac arrest			
*Time CPR started	X		
Time of ROSC			
*Rate	100-120	100-120	
*Depth	≥ 2 in	2-2.4 in	
*Continuous vs interrupted	30:2	30:2	
*Rotate compressors	Every 1-2 minutes	Every 2 minutes	
*Early AED/defibrillator use	Early AED or 30 sec - 2 min CPR if unwitnessed	CPR with early AED use	
*Defibrillation energy	Manufacturer's recommendation or Maximum		Biphasic > monophasic Manufacturer's recommendation or Maximum
*IV or IO	X		Either
*Oxygen	Highest flow possible		High flow
*Initial Vasopressor	Epinephrine or Vasopressin		Epinephrine
*Subsequent Vasopressor	Epinephrine		Epinephrine
*Initial Antiarrythmic	Amiodarone		Amiodarone
*Subsequent Antiarrythmic	Lidocaine		Lidocaine
*Magnesium if Torsades	Yes		
*Tidal volume	Limited	Chest rise – 500-600 ml = 6-7 ml/kg – avoid excessive	
*Ventilation rate BVM	30:2	30:2	
*Initial advanced airway	Supraglottic		No preference No interruption
*Back-up advanced airway	Endotracheal		

Data element	NASEMSO[1]	AHA ECC 2015 BLS[3]	AHA ECC 2015 ALS[4]
*Ventilation rate airway	Every 6-8 seconds	Every 6 seconds	
*$ETCO_2$ monitoring	Yes		X
*12 lead ECG if ROSC	X		X
*EMS Cooling	Consider		Not recommended
*Mechanical CPR			Consider for transport
OHCA notification			
*Hospital bypass	Consider		Consider
Online Medical Control (OLMC)			
Code 3 Transport			
*Termination of Resuscitation (TOR) protocol	X		X
Defibrillator download			
Review of CPR Quality	*X*		
**Time of EMS on scene*	*X*		
**Time of EMS to patient*	*X*		
**Time of 1st shock*	*X*		
**Bystander CPR performed?*	*X*		

*Guideline recommendation

X mentioned in the guideline

Guideline recommendation not abstracted.

Table 2. STEMI EMS protocol data elements

Data element	NASEMSO[1]	AHA ECC 2015[5, 6]
Protocol effective date		
*Determination of cardiac chest pain equivalent symptoms	X	X
Upper age limit		
*Time of onset of symptoms	X	X
*Time of EMS on scene	X	
*Time of initial 12 lead ECG	X	X
*Time of STEMI Activation (notification)	X	
*Oxygen to keep the $SpO_2 \geq 94\%$	X	X
*Aspirin	160-325 mg	160-325 mg
*12 lead ECG	X	X
12 lead ECG acquisition before NTG		
*12 lead ECG interpretation	Paramedic +- autoanalyzer	Paramedic +- autoanalyzer
*Right-sided ECG leads if inferior MI		X
*No NTG if RV MI	X	X
*EKG transmitted		Consider
*IV established	X	
*Nitroglycerin (NTG)	X	X
*Nitroglycerin BP limit	90 & 100	<90 or 30 below baseline
*Nitroglycerin Erectile Dysfunction Contraindication	X	X
*Analgesic	X	Morphine
*STEMI Notification	X	X
*EMS fibrinolytics		Consider
*Hospital bypass	X	X
Direct to cath lab		
*12 lead ECG delivered to hospital	X	
Online Medical Control (OLMC)		
Code 3 Transport		
Time of Aspirin administration	*X*	
Time of STEMI identification	*X*	
Time of PCI center arrival	*X*	
Cardiac monitor	*X*	

*Guideline recommendation

X mentioned in the guideline

Guideline recommendations not abstracted.

Table 3. Stroke EMS protocol data elements

Data element	NASEMSO[1]	2010[7]	2013[8]
Protocol effective date			
*Time of onset of symptoms (last seen normal)	X 3-4.5 med/6 for cath	X 3-4.5 med/6 for cath	
*Stroke evaluation method	Specific validated stroke score	X	Prehospital stroke assessment tool
*Blood glucose determination (CBG)	X	X	X
*Hypoglycemia treatment	CBG < 60		CBG < 60
*Oxygen to keep the $SpO_2 \geq 94\%$	X		X
*IV established	Avoid multiple		X
*12 lead ECG	If possible		
EMS Fibrinolytics			
*Stroke Notification		X	X
*Hospital bypass	Nearest stroke center or stroke capable facility	X	X
Online Medical Control (OLMC)			
*Head of bed elevated	15-30 if BP > 100		
Code 3 Transport			
Stroke checklist	*X*		
Do not treat hypertension	*X*		
Cardiac monitor	*X*		*X*

*Guideline recommendation

X mentioned in the guideline

Guideline recommendations not abstracted.

Table 4. Protocol Effective Date

	Rural N (%)	Non-rural N (%)
OHCA Protocol Effective Date §	Total = 60	Total = 35
Within 1 year	30 (50%)	28 (80%)
Within 2 years	39 (65%)	35 (100%)
Within 4 years	46 (77%)	35 (100%)
5 or more years	6 (10%)	0 (0%)
Undated	8 (13%)	0 (0%)
STEMI Protocol Effective Date	Total = 60	Total = 35
Within 1 year	34 (57%)	28 (80%)
Within 2 years	44 (73%)	34 (97%)
Within 4 years	49 (82%)	34 (97%)
5 or more years	5 (8%)	1 (3%)
Undated	6 (10%)	0 (0%)
Stroke Protocol Effective Date	Total = 57	Total = 35
Within 1 year	32 (56%)	28 (80%)
Within 2 years	40 (70%)	34 (97%)
Within 4 years	48 (84%)	34 (97%)
5 or more years	4 (7%)	1 (3%)
Undated	5 (9%)	0 (0%)

§ Chi-square p-value < 0.05 for Rural vs Non-rural

Table 5. OHCA data elements present in protocols from EMS agencies

	Rural N (%)	Non-rural N (%)
(listed by decreasing sum of N Rural + N Non-rural)		
*Initial vasopressor	60 (100%)	35 (100%)
*Initial vasopressor	60 (100%)	35 (100%)
*Initial advanced airway	60 (100%)	35 (100%)
*Initial anti-arrhythmic	58 (97%)	35 (100%)
*Early AED/defibrillator use (detailed in Table 3)	56 (93%)	35 (100%)
*Defibrillation energy	56 (93%)	35 (100%)
*Magnesium if Torsades §	52 (87%)	**35 (100%)**
*Chest compression rate § (detailed in Table 3)	51 (85%)	**34 (97%)**
*IV or IO	55 (92%)	28 (80%)
*Chest compression type (detailed in Table 3)	49 (82%)	28 (80%)
*High flow oxygen §	**51 (85%)**	22 (63%)
*Termination of Resuscitation (TOR) protocol §	39 (65%)	**32 (91%)**
*$ETCO_2$ monitoring §	37 (62%)	**34 (97%)**
*Ventilation rate - airway	40 (67%)	28 (80%)
*Chest compression depth §	34 (57%)	**28 (80%)**
*Ventilation rate - BVM (detailed in Table 3) §	33 (55%)	**28 (80%)**
*Subsequent anti-arrhythmic	37 (62%)	18 (51%)
*12 lead ECG if ROSC §	25 (42%)	**24 (69%)**
*EMS Cooling	26 (43%)	20 (57%)
*Back-up advanced airway	27 (45%)	10 (29%)
*Rotate compressors	20 (33%)	16 (46%)
*Initial cardiac rhythm	18 (30%)	17 (49%)
Time of cardiac arrest	20 (33%)	14 (40%)
*Subsequent vasopressor	19 (32%)	15 (43%)
*Hospital bypass specified	19 (32%)	15 (43%)
*Rapid determination of cardiac arrest	10 (17%)	10 (29%)
*Tidal volume	7 (12%)	5 (14%)
*Mechanical CPR	6 (10%)	5 (14%)
Specific OHCA notification	4 (7%)	3 (9%)
*Time CPR started	3 (5%)	4 (11%)
Time of ROSC	3 (5%)	3 (9%)
Defibrillator download	4 (7%)	0 (0%)
Online Medical Control (OLMC) required	1 (2%)	0 (0%)
Code 3 Transport required	0 (0%)	0 (0%)

*Guideline recommendation[1,2,3,4]

§ Chi-square p-value < 0.05 for Rural vs Non-rural – **larger value**

Table 6. Selected OHCA data elements present in protocols from EMS agencies

	Rural N (%)	Non-rural N (%)
*Early AED/defibrillator use		
Yes	18 (30%)	20 (57%)
After 2 min CPR	6 (10%)	0 (0%)
If downtime > 5 min, after 2 min CPR	9 (15%)	14 (40%)
If unwitnessed, then 1-2 min CPR	22 (37%)	0 (0%)
AHA Guidelines	1 (2%)	1 (3%)
Not listed	4 (7%)	0 (0%)
*Chest compression rate		
80-100	1 (2%)	0 (0%)
about 100	9 (15%)	0 (0%)
100	22 (37%)	19 (54%)
100-120	12 (20%)	6 (17%)
110	6 (10%)	5 (14%)
110-120	0 (0%)	3 (9%)
AHA Guidelines	1 (2%)	1 (3%)
Not listed	9 (15%)	1 (3%)
*Chest compression type		
Interrupted	29 (48%)	13 (37%)
Continuous	14 (23%)	14 (40%)
Both	3 (5%)	0 (0%)
AHA Guidelines	3 (5%)	1 (3%)
Not listed	11 (18%)	7 (20%)
*Ventilation rate with BVM		
Every 6 seconds	3 (5%)	0 (0%)
Every 6-8 seconds	3 (5%)	0 (0%)
10:1	6 (10%)	8 (23%)
30:2	13 (22%)	6 (17%)
6-8/minute	1 (2%)	6 (17%)
10-12/minute	6 (10%)	8 (23%)
AHA Guidelines	1 (2%)	0 (0%)
Not listed	27 (45%)	7 (20%)
*Ventilation rate with advanced airway		
Every 6-8 seconds	32 (53%)	13 (37%)
30:2	6 (10%)	10 (29%)
> every 5 sec	1 (2%)	0 (0%)
10-12/minute	0 (0%)	5 (14%)
AHA Guidelines	1 (2%)	0 (0%)
Not listed	20 (33%)	7 (20%)

Table 7. STEMI data elements present in protocols from EMS agencies

	Rural N (%)	Non-rural N (%)
(listed by decreasing sum of N Rural + N Non-rural)		
*12 lead ECG required	60 (100%)	35 (100%)
*IV established	60 (100%)	35 (100%)
*Nitroglycerin (NTG) administration	60 (100%)	35 (100%)
*Analgesic administration	60 (100%)	35 (100%)
*Aspirin administration (detailed below)	59 (98%)	35 (100%)
*Nitroglycerin BP limit	56 (93%)	35 (100%)
*12 lead ECG interpretation	54 (90%)	35 (100%)
*Nitroglycerin Erectile Dysfunction contraindication	54 (90%)	35 (100%)
*Hospital bypass specified §	46 (77%)	**34 (97%)**
*STEMI notification required	47 (78%)	31 (89%)
*Determination of cardiac chest pain equivalent §	**51 (85%)**	23 (66%)
*EKG transmitted	39 (65%)	18 (51%)
*Oxygen to keep the $SpO_2 \geq 94\%$	32 (53%)	20 (57%)
*12 lead ECG delivered to hospital	28 (47%)	23 (66%)
Upper age limit	25 (42%)	8 (23%)
*Time of onset of symptoms	25 (42%)	8 (23%)
*No NTG if RV MI	16 (27%)	8 (23%)
12 lead ECG acquisition before NTG §	**19 (32%)**	4 (11%)
*Right-sided ECG leads if inferior MI §	**8 (13%)**	0 (0%)
Code 3 Transport required §	1 (2%)	**6 (17%)**
Online Medical Control (OLMC) required	4 (7%)	0 (0%)
*Time of initial 12 lead	1 (2%)	3 (9%)
*Time of EMS on scene §	0 (0%)	**3 (9%)**
Direct transfer to cath lab §	0 (0%)	**3 (9%)**
*Time of STEMI notification	0 (0%)	1 (3%)
*EMS fibrinolytics administration	0 (0%)	0 (0%)

§ Chi-square p-value < 0.05 for Rural vs Non-rural – **larger value**

*Aspirin administration		
162 mg	11 (18%)	3 (9%)
162-324 mg	10 (17%)	4 (11%)
243-324 mg	0 (0%)	1 (3%)
324 mg	35 (58%)	27 (77%)
Amount not specified	3 (5%)	0 (0%)
Not listed	1 (2%)	0 (0%)

*Guideline recommendation[1,5,6]

Table 8. Stroke data elements present in protocols from EMS agencies

	Rural N (%)	Non-rural N (%)
(listed by decreasing sum of N Rural + N Non-rural)		
*Time of onset of symptoms (detailed below)	57 (100%)	35 (100%)
*Hypoglycemia treatment	57 (100%)	34 (97%)
*IV established	55 (97%)	35 (100%)
*Stroke evaluation method (detailed below) §	52 (91%)	**35 (100%)**
*Blood glucose determination (CBG) §	**55 (97%)**	27 (77%)
*Head of bed elevated §	26 (46%)	**32 (91%)**
*Stroke notification required	28 (49%)	20 (57%)
*12 lead ECG	24 (42%)	19 (54%)
*Hospital bypass specified	24 (42%)	18 (51%)
*Oxygen to keep the $SpO_2 \geq 94\%$	21 (37%)	20 (57%)
Code 3 Transport	6 (11%)	**11 (31%)**
*EMS Fibrinolytics	0 (0%)	0 (0%)
Online Medical Control (OLMC) required	0 (0%)	0 (0%)
§ Chi-square p-value < 0.05 for Rural vs Non-rural – **larger value**		
*Time of onset of symptoms (hours since last seen normal)		
2	4 (7%)	0 (0%)
2-3	1 (2%)	0 (0%)
3	17 (30%)	6 (17%)
3.5	2 (4%)	1 (3%)
3.5/6	6 (11%)	4 (11%)
3 if thrombolytic /6 if intravascular intervention	1 (2%)	0 (0%)
4	1 (2%)	6 (17%)
4.5	9 (16%)	9 (26%)
5	0 (0%)	5 (14%)
6	12 (21%)	3 (9%)
Yes	4 (7%)	1 (3%)
Not listed	3 (5%)	0 (0%)
*Stroke evaluation method §		
Cincinnati Prehospital Stroke Scale	16 (28%)	21 (60%)
Cincinnati Prehospital Stroke Scale &/or Los Angeles Prehospital Stroke Screen	1 (2%)	0 (0%)
F.A.S.T. and Cincinnati Prehospital Stroke Scale	1 (2%)	0 (0%)
FAST	15 (26%)	5 (14%)
Facial droop. Arm drift. Abnormal speech with "You can't teach an old dog new tricks".	3 (5%)	0 (0%)
H&P	8 (14%)	0 (0%)
Modified Los Angeles Prehospital Stroke Screen	6 (11%)	9 (26%)
Not listed	8 (14%)	0 (0%)
*Guideline recommendation[1,7,8]		

Table 9. Summary of evidence-based guidelines protocol element presence in EMS protocols

	Compliance (%)			
	Rural		Non-rural	
	Mean	Range	Mean	Range
All 3 Systems of Care§	61%	34-76%	**67%**	57-79%
OHCA§	57%	21-79%	**65%**	46-79%
STEMI	63%	40-75%	65%	55-75%
Stroke§	67%	0-100%	**79%**	60-100%

§ t-test $p < 0.05$ for Rural vs Non-rural – **larger value**

Table 10. Summary of evidence-based guidelines protocol element presence in EMS protocols

General comments

Some protocols did not contain a physician (EMS medical director) signature.

A few “protocols” were exceptions to a multi-agency protocol.

OHCA comments

Metronome or CPR feedback device whenever possible.

Passive oxygenation via nasal cannula until 3rd EMS provider arrives.

Central Line access is preferred over IO placement in Cardiac Arrest.

Interrupt compressions only per AED/Airway procedures.

Do not transport until ROSC.

STEMI comments

Administration of clopidogrel, heparin or metoprolol and blood draw for labs

Labetalol for hypertension

Lidocaine for PVC if ischemia

Do not delay administration of aspirin to obtain 12 lead.

ECG before ASA, NTG, morphine.

Long distance to cath lab or other hospitals.

Stroke comments

Patient is not a candidate for stroke therapy if they have a valid POLST with DNR or Comfort Measures Only

POLST "Comfort Measures Only" do not get Stroke Activation.

Must be less than 80 years old.

Thiamine if alcoholism.

Labetolol if BP > 190/110.

NTG if DBP > 135.

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Appendix A – Model Protocols

High Performance CPR - Adult

Ventricular Fibrillation/Pulseless Ventricular Tachycardia (VF/VT)

Cardiac Chest Pain & STEMI

Stroke

CPR - HIGH PERFORMANCE - ADULT

EMR, EMT, AEMT, EMT-I, Paramedic

INDICATIONS:

Any adult patient with cardiac arrest (unresponsive with absent or abnormal respirations) without a POLST Do Not Resuscitate (DNR) order.

PRECAUTIONS:

Do not delay the initiation of chest compressions.

Pulse check should not take more than 5-10 seconds. If definite pulse is not detected, then begin chest compressions.

PROCEDURE

- Manual chest compressions *(intermittent at 30:2 or continuous),* rapid AED/defibrillation analysis, and, if indicated, shock at energy level per manufacturer recommendation
- Chest compressions at 100-120 /minute
- Compression depth of at least 2-2.4" (5-6 cm)
- Rotate chest compressors at least every 2 minutes
- High flow 100% O_2
- Ventilations:
  - Bag-Valve-Mask (BVM) ventilations:
    Intermittent at 30:2 or every 10th continuous chest compression
  - Artificial airway – asynchronous ventilations every 6 seconds
  - Tidal volume just to get visible chest rise
- IV or IO with crystalloid
- $ETCO_2$ monitoring
- Advanced airway insertion with no interruption of chest compressions
- If ROSC (return of spontaneous circulation) occurs12 lead ECG without delay in transport

  Report:Time of cardiac arrest
  - Time of EMS on scene
  - Whether or not bystander CPR was performed
  - Time of EMS to patient
  - Time EMS started CPR
  - Initial cardiac rhythm
  - Time of 1st shock (defibrillation)
  - Time of ROSC

  Notify destination hospital of patient with cardiac arrest and ROSC

  Transport to hospital with appropriate capabilities
- If no ROSC consider TOR (termination of resuscitation) protocol
- Review of CPR quality using defibrillator download

VENTRICULAR FIBRILLATION/ PULSELESS VENTRICULAR TACHYCARDIA (VF/VT)

SUBJECTIVE:

Loss of consciousness.

OBJECTIVE:

Unresponsive and pulseless with absent or abnormal respirations.
AED shows “shockable rhythm”.
Cardiac monitor shows ventricular fibrillation or ventricular tachycardia.

ASSESSMENT:

Ventricular fibrillation or pulseless ventricular tachycardia (VF/VT).

TREATMENT:

EMR:	• High Performance CPR • AED or defibrillator use as soon as available
EMT:	• Supraglottic airway after chest compressions, AED/defibrillator use and IV/IO access with no interruption of CPR
AEMT:	• IV or IO with crystalloid
EMT-I:	• Initial defibrillation with single shock at manfacturer’s recommended energy setting • Epinephrine 1:10,000 1mg IV or IO - repeat every 3-5 minutes • Subsequent defibrillation with single shock at manfacturer’s recommended energy setting • Amiodarone: 1st dose 300 mg or 5 mg/kg; 2nd dose 150 mg/kg • Lidocaine secondary to amiodarone: 1.5 mg/kg
Paramedic:	• Endotracheal intubation if supraglottic airway not placed with no interruption of CPR • Magnesium sulfate - if torsades de pointes

CARDIAC CHEST PAIN

SUBJECTIVE:

Chest or epigastric discomfort lasting minutes to hours – not usually seconds or days

Discomfort may originate, be limited to, or may radiate to neck, jaw, shoulder, inner arm or elbow

May be associated with diaphoresis, nausea, vomiting, SOB , weakness, lightheadedness or palpitations.

May be brought on by exertion, stress or occur spontaneously.

Relieved by rest or nitroglycerine.

May have PMH of bypass surgery, angioplasty, angina, heart attack or myocardial infarction.

Atypical presentations are common and may include no discomfort.

OBJECTIVE:

Examination may be normal. Patient may appear ashen or sweaty. Patient may be hypotensive, bradycardic or have evidence of pulmonary edema (rales). Cardiac rhythm is monitored to detect the occurrence of ventricular or atrial dysrhythmias.

ASSESSMENT:

Diagnosis of cardiac chest pain or heart equivalent discomfort is made on the basis of the patient's history. Other causes of chest discomfort include chest wall trauma, esophageal reflux, gastritis, peptic ulcer disease, pneumonia, pericarditis, pleurisy, pancreatitis, costochondritis, gall bladder disease, aortic dissection, aortic aneurysm, pulmonary embolism and anxiety.

TREATMENT:

EMR:	• 12 lead ECG • Aspirin - *160-325* mg chewed – give even if taking other anticoagulant or "blood thinner" medications • Oxygen only to maintain SpO_2 = 94% or above
EMT:	• May assist with self-administration of patient's own nitroglycerin
AEMT:	• Nitroglycerin - if systolic BP > (*90-100)* mm Hg and no recent erectile dysfunction medication • IV (20 or 18 gauge preferred) with saline lock unless crystalloid or medications indicated
EMT-I:	• Cardiac monitor • Morphine or Fentanyl
Paramedic:	• STEMI protocol - next page

ST ELEVATION MI (STEMI)

SUBJECTIVE:

Heart equivalent chest discomfort AND

OBJECTIVE:

Defibrillator 12 lead ECG meeting one of these 3 criteria:

New LBBB (left bundle branch block,

ST elevation, beginning at the J point:

≥ 1 mm ST elevation in
2 contiguous lateral leads (I, aVL, V_4, V_5 & V_6) OR
2 contiguous inferior leads (II, III, & aVF)

≥ 2 mm ST elevation in two contiguous chest leads (V_1, V_2, & V_3)

OR Automatic ECG interpretation of "STEMI" with paramedic confirmation

If patient had ventricular fibrillation or ventricular tachycardia converted to perfusing rhythm with stable vital signs, then ECG must be at obtained after at least 5 minutes of the converted rhythm.

ASSESSMENT:

Acute myocardial infarction with ST elevation is usually best managed with rapid transport to a hospital offering emergent cardiac catheterization services for diagnosis and treatment.

TREATMENT:

EMR:
EMT:
AEMT: *12 lead ECG transmission to hospital if paramedic not available*
EMT-I

Paramedic:

- Minimize on-scene time and transport the patient with a STEMI to a hospital with cath lab capability.
- Notify the receiving hospital of STEMI patient as soon as possible
- *Right-sided ECG leads if inferior MI*
- *No nitroglycerin (NTG) if right ventricular infarction*
- Leave a copy of the 12 lead ECG at the hospital
- Report:
  Time of onset of symptoms
  Time of EMS on scene
  Time of initial 12 lead ECG
  Time of STEMI identification
  Time of aspirin administration
  Time of cath lab hospital (PCI center) notification

CEREBRAL VASCULAR ACCIDENT (CVA OR STROKE)

SUBJECTIVE:

Sudden onset of focal neurological deficit - commonly unilateral paralysis (extremity or facial weakness typically on one side of the body) or aphasia (absent, abnormal, garbled or slurred speech). Patients with these symptoms of less than *(3, 4.5, 6)* hours duration may be candidates for thrombolytic or other interventional therapy.

Other symptoms of stroke may include disturbances in consciousness, ataxia, visual loss, diplopia (double vision), dysphagia (difficulty swallowing), seizure, coma or death.

These symptoms may be accompanied by nausea, vomiting, or headache.

Risk factors for stroke include prior stroke or TIA, atrial fibrillation, hypertension, angina or heart attack, diabetes, hypercholesterolemia, obesity, smoking history, and illicit drug use (i.e. meth, cocaine, synthetic marijuana).

OBJECTIVE:

Patient assessment should include the evaluation of pupils, speech, language, motor responses and sensations. Limbs should be evaluated for equal strength and motion. Neurological exam findings may change with time. Monitor blood pressure, pulse, respirations, cardiac rhythm and blood sugar.

ASSESSMENT:

Diagnosis of stroke (CVA) is made on the basis of patient history and physical exam. "Stroke mimics" include trauma, hypoglycemia, seizure disorder, psychiatric disorder and drug ingestion.

TREATMENT:

EMR:	• If the patient was last seen normal within the previous *(3, 4.5, 6)* hours, he/she may be a candidate for thrombolytic or other interventional therapy. Reduce scene time, transport to the nearest stroke center and report: *Prehospital stroke assessment tool, such as Cincinnati Prehospital Stroke Scale or Los Angeles Prehospital Stroke Screen.* Specific time (hh:mm) the patient was last seen normal, and the names and phone numbers of any witnesses. • Notification of hospital of stroke patient. • 12 lead ECG - if this does not delay patient care or transport • Oxygen only to maintain SpO_2 above 94% . Elevate head of bed 20-30° if tolerated
EMT:	• Check blood sugar • Oral glucose for hypoglycemia if airway is protected
AEMT:	• IV with saline lock • Glucose IV or pediatric IO for hypoglycemia
EMT-I: **Paramedic:**	• Cardiac monitor • Adult IO