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## **From the Desk of the Medical Director**

### The Use of Epinephrine in the Prehospital Setting

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Medication errors are a frequent problem in hospitals and clinics and pre-hospital systems are not immune.<sup>1,2</sup> The Santa Clara County EMS agency, specifically the Medical Director, is responsible for investigating and preventing these errors in the pre-hospital setting.<sup>3</sup> The following discussion provides background information about medication errors in general and epinephrine use in particular in Santa Clara County, outlines our strategy for minimizing this error, and discusses the tradeoffs of using epinephrine auto-injectors.

#### **Background**

The Santa Clara County EMS Agency receives reports of medication errors through our Countywide Quality Improvement program. The majority of these errors are identified as isolated cases that are handled directly with the individual EMS provider and agency. Most issues are resolved through individual training and monitoring that require no system-wide intervention.

Our standard approach in investigating issues identified through the Quality Improvement program begins with a thorough investigation of the root causes of the errors, which may, if appropriate, lead to the implementation of interventions designed to prevent the identified errors in the future. Whenever possible, and appropriate, most cases are handled through individual training and education with the responsible individual. Sometimes, we find that a broader system-wide training approach, coupled with clarification or refinement of protocols, is necessary. These changes are incorporated into our annual update process in consultation with our stakeholder groups. Rarely, when prior interventions do not appear effective and the error is deemed to cause an immediate risk to public safety, an urgent system-wide approach outside of our annual process is necessary. This may take the form of an Administrative Order modifying protocols, or the addition or deletion of a procedure or medication through the annual update process.

The use of the medication epinephrine in the 1:1,000 concentration has been identified through the Quality Improvement process as requiring the attention of the Medical Director. In 2004, the first case of potentially inappropriate epinephrine administration came to my attention. This case appeared to be isolated in nature and the mitigation plan included individual counseling and training. The 2005 Allergic Reaction/Anaphylaxis Protocol (A12) was also modified to limit the use of SQ epinephrine to cases of “shock” and IV epinephrine to cases of “Severe Shock and Impending Respiratory Arrest”. System-wide training for all ALS agencies that addressed the

hazards of inappropriate IV and SQ epinephrine administration was completed in both the 2005 and 2006 Train-the Trainer sessions. There were no further reports of administration errors until recently.

In late August and September 2007, additional cases of epinephrine administration in routes other than identified within protocol were brought to my attention. A root cause analysis continues, although we have determined that these errors tend to be due to the following:

- 1) Potential misunderstanding of the level of treatment indicated for hives, asthma, and anaphylaxis leading to use of epinephrine when not clinically indicated
- 2) Incomplete understanding of the toxicity of epinephrine
- 3) Possible confusion about the concentration of the medication in the unlabeled syringe
- 4) Failure to adhere to the Allergic Reaction/Anaphylaxis (A12) protocol that states that epinephrine SQ is limited to patients in “Shock” and IV epinephrine is limited to cases of “Severe Shock and Impending Respiratory Arrest”
- 5) Possible misunderstanding of the wording of Allergic Reaction/Anaphylaxis (A12) protocol. This protocol specifies that Epinephrine (1:1000) 0.02mg/kg can be given via ET (if no IV Access) which may lead some to misread to mean that if you have IV access the 1:1,000 concentration is delivered by IV not by ET.

Some of these root causes were very similar to the 2004 case.

Misadministration of epinephrine is a well documented medication error in the prehospital setting.<sup>1</sup> Many adverse effects have been reported including cardiac ischemia, acute myocardial infarction, respiratory arrest, ventricular dysrhythmias, coronary artery spasms, and fatal intracranial bleeding.<sup>4-9</sup> Confusing epinephrine 1:1000 with 1:10,000 has also been described<sup>10</sup>. Similar outcomes have been found in Santa Clara County in our ongoing investigation.

### **Strategy for Preventing Epinephrine Administration Errors**

Based on this new information it appears that the initial interventions (individual training, protocol refinement, communication with training officers) have been ineffective and a new strategy has to be employed. This new strategy has two primary objectives:

- 1) Eliminate the risk that epinephrine 1:1000 can be given IV
- 2) Improve appropriate use of IV and SQ epinephrine through protocol revision, system wide training, implementation of provider agency monitoring procedures and base physician oversight

Since the administration of epinephrine 1:1000 is potentially lethal, achieving the first objective requires urgent action that could not be accommodated by our regular meeting schedule and budget planning procedures. I have reviewed various options for achieving this objective which included improved labeling, complete removal of epinephrine 1:1000, or substitution of the vials of epinephrine 1:1000 with epinephrine auto-injectors. Improved labeling, though potentially part of the solution, does not completely prevent accidental IV administration. Complete removal of epinephrine 1:1000 would eliminate the potential of IV administration, but it took away the option of therapeutic SQ administration. Unlike the above noted options, the epinephrine auto-injectors allowed us to continue prehospital treatment with epinephrine 1:1000 but will prevent accidental IV administration of this concentration.

Meeting objective two (2) has been partially achieved through protocol revisions and the requirement for base physician contact. The necessary training and monitoring procedures used to promote compliance with this objective are expected to take approximately one (1) year to complete.

### **The Tradeoffs of using Epinephrine Auto-injectors**

Though the epinephrine auto-injectors have the great advantage of preserving the ability of paramedics to continue appropriate therapy for anaphylaxis patients while eliminating the possibility of giving a potentially lethal dose of IV epinephrine 1:1000, they are not the perfect solution. Some of the negatives aspects are:

- 1) The IM route is more effective over SQ route. Auto-injector needles are too short for consistent IM administration
- 2) Eliminates the ability to give EPI via ET tube in cases where IV cannot be established
- 3) Eliminates the ability to give nebulized epi for croup
- 4) They are more expensive than vials of epinephrine 1:1000

In an effort to mitigate the negative impacts of the replacement of 1:1,000 epinephrine with autoinjectors the following factors were taken into consideration or implemented:

- 1) While the short needle length cannot guarantee that the dose is received IM, by using the anterolateral thigh the chances of giving an IM dose is increased. SQ, though not optimal, is effective.
- 2) ET administered drugs have been shown to be ineffective in cardiac arrest (at least at the 2x doses generally used)<sup>11,12</sup> and no cases in Santa Clara County were identified where a patient survived out-of-hospital asystole or PEA when given these drugs via ET tube. This is the primary reason that adult IO is recommended by the American Heart Association for patients in cardiac arrest when an IV cannot be established<sup>13</sup>. Optional adult IO was introduced in the annual protocol revisions for 2008 to address this administration route. In addition ET administration for other drugs was retained until the

full changeover to IO is complete. In summary, ET administration is not the only option, nor is it the preferred option, in failed IV attempt situations.

- 3) While severe croup can be improved with nebulized racemic epinephrine, I do not believe it absolutely has to happen during short pre-hospital transport times.
- 4) The cost of auto injectors is greater than vials, but overall is a modest difference. While every effort is made to provide for a phased implementation to address budgetary processes, given the potential lethal outcome requiring the urgency of the change, it was felt that normal budgeting and planning processes could not be used.

Should subcutaneous epinephrine be needed for anaphylaxis or severe bronchospasm, Epinephrine 1:1000 auto injectors (1 adult, 1 pediatric) will be added to the ALS inventory list. Once these are available, all epinephrine 1:1000 vials are to be removed from all ALS drug inventories. During this interim time period, in cases of anaphylaxis, all use of IV epinephrine (1:10,000) will require base hospital physician clearance prior to administration. Base hospital contact is not required for IV epinephrine administration in the setting of Cardiac Arrest. The Santa Clara County EMS Agency will monitor epinephrine usage carefully over the next year paying particular attention to intra-agency safety monitoring procedures.

## **Summary**

Medication errors are a frequent problem in all phases of medical care, from outpatient clinics, pre-hospital and hospitals. They often, particularly in the case of epinephrine, have catastrophic consequences both for the patient and the well-meaning provider. Error reduction requires a process of detection, root cause analysis, intervention (training, revised procedures, and engineering safety solutions) and monitoring. In the end our goal is to provide the safest possible system for the patient and for you as the provider.

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