Autoinjectable Epi is not Always Needed

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What is happening in the real world?
AIE is often not prescribed
National study of US emergency department visits for acute allergic reactions, 1993 to 2004

- Objectives:
  - To characterize ED visits for acute allergic reactions and to evaluate national trends in ED management.

- Methods:
  - The National Hospital Ambulatory Medical Care Survey was used to identify a nationally representative sample of ED visits between 1993 and 2004.
  - Cases with a diagnosis of acute allergic reaction were identified by International Classification of Diseases, Ninth Revision (ICD-9) codes (9950, 9951, 9952, 9953, 9956).

Gaeta Ann All Asthma Imunol 2007; 98:360–365
National study of US emergency department visits for acute allergic reactions, 1993 to 2004

• Results:
  • A total of 12.4 million allergy-related ED visits occurred from 1993 to 2004, representing 1.0% (95% confidence interval, 0.93%-1.10%) of all ED visits or 1.03 million ED visits per year.
  • The number of allergy-related ED visits remained relatively stable, averaging 3.8 per 1,000 US population per year (95% confidence interval, 3.4–4.1; P for trend = .39).
  • Although 63% of all visits were coded as urgent, only 4% required hospitalization.
  • ED staff prescribed medications in 87% of visits, especially antihistamines (62%; P for trend = .29).
  • Increases were noted from 1993 to 2004 for:
    • corticosteroids (22% to 50%; P < .001),
    • antihistamines (7% to 18%; P < .001)
    • inhaled B-agonists (2% to 6%; P = .008).
  • Epinephrine use was infrequent and declining (19% to 7%; P = .04)

Gaeta Ann All Asthma Imunol 2007; 98:360–365
Results:

• In the subset with the most severe allergic reactions:
  • 63% received an antihistamine
  • 61% a corticosteroid,
  • 38% an H2 blocker.
  • Only 50% of anaphylaxis cases received epinephrine, and 13% received a B-agonist.
  • The NHAMCS data reveal that ED physicians rely on these second-line agents for the treatment of the most acute allergic reactions.

• Conclusions:
  • The present analysis confirmed the rarity of epinephrine use in the larger group with acute allergic reaction, but it also revealed that epinephrine was administered in only 50% of identified anaphylaxis cases. The observed decline in epinephrine use during the 12-year study period is of particular interest.

Gaeta Ann All Asthma Imunol 2007; 98:360–365
Prescriptions for self-injectable epinephrine and follow-up referral in emergency department patients presenting with anaphylaxis

• Background:
  • Anaphylaxis guidelines recommend that patients with a history of anaphylactic reaction should carry self-injectable epinephrine and should be referred to an allergist.

• Objective:
  • To evaluate how frequently patients dismissed from the emergency department after treatment for anaphylaxis received a prescription for self-injectable epinephrine or allergist referral.

• Methods:
  • A retrospective medical record review identified patients with anaphylaxis in a community-based study from 1990 through 2000.
  • Records of patients with ICD-9 codes representing anaphylaxis were reviewed, and a random sample of patients with associated diagnoses was also reviewed.
  • Patients who met the criteria for diagnosis of anaphylaxis were included in the study.

Prescriptions for self-injectable epinephrine and follow-up referral in emergency department patients presenting with anaphylaxis

**Results:**
- Among 208 patients identified with anaphylaxis, 134 (64.4%) were seen in the emergency department and discharged home.
- **On dismissal:**
  - 49 patients (36.6%; 95% CI 28.4%-44.7%) were prescribed self-injectable epinephrine,
  - 42 patients (31.3%; 95% CI, 23.5%-39.2%) were referred to an allergist.
Prescriptions for self-injectable epinephrine and follow-up referral in emergency department patients presenting with anaphylaxis

• Results:
  • Treatment with epinephrine in the emergency department (odds ratio, 3.6; 95% CI, 1.6-7.9; P = .001) and insect sting as the inciting allergen (odds ratio, 4.0; 95% CI, 1.6-10.5; P = .004) were significantly associated with receiving a prescription for self-injectable epinephrine.
  • Patient age younger than 18 years was the only factor associated with referral to an allergist (P = .007).

• Conclusions:
  • Most patients dismissed after treatment for anaphylaxis did not receive a self-injectable epinephrine prescription or allergist referral.
  • Emergency physicians may be missing an important opportunity to ensure prompt treatment of future anaphylactic reactions and specialized follow-up care.

Longitudinal study of 954 patients with stinging insect anaphylaxis (SIA)

Methods:

• Identified all patients with an ED visit or hospitalization for SIA during 2002-2008 in the MarketScan Database using ICD9 codes for anaphylaxis (index date was the initial ED visit or hospitalization).

• Patients were required to have continuous full insurance coverage for 1 year or more before and after index. They examined patient factors during the pre-index period, characteristics of the index event, and outcomes during the post-index period.

• Multivariable logistic regression was used to identify independent predictors of receiving preventive anaphylaxis care.

Rudders Ann All Asthma Immunol
2013;111:199-204
Results:

- Identified 954 patients with an ED visit or hospitalization for SIA (mean [SD] age, 46 [19] years; 41% female).
- A total of 85% of patients were discharged directly from the ED.
  - For those hospitalized, the mean hospital stay was 1 day, and 50% spent time in the intensive care unit.
  - Cardiorespiratory failure occurred in 27% of those hospitalized.
- During the post-index period, 69% filled 1 or more epinephrine autoinjector prescription (median 1d).
- Only 14% had 1 or more allergist/immunologist visit (median 34d).
- Via multivariable analysis, factors independently associated with A/I consult within 60 days of an index visit for anaphylaxis were:
  - higher household income,
  - filling 1 or more EAI prescription before the index event,
  - an A/I visit before the index event.

Conclusion:

- Although two-thirds of patients filled a prescription for an epinephrine autoinjector after an ED visit or hospitalization for SIA, only 14% of patients received follow-up care by an allergist/immunologist.
- This missed opportunity to provide venom immunotherapy, an essentially curative therapy, unnecessarily places patients at risk for recurrent anaphylaxis.
Table 2
Emergency department and hospital clinical presentation and treatment for stinging insect anaphylaxis

<table>
<thead>
<tr>
<th>Clinical course</th>
<th>Finding (N = 954)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ED course (n = 807)</strong>*</td>
<td></td>
</tr>
<tr>
<td>Cardiorespiratory failure, No. (%)</td>
<td>54 (7)</td>
</tr>
<tr>
<td>Hypotension</td>
<td>51 (6)</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>1 (0.1)</td>
</tr>
<tr>
<td>Respiratory arrest</td>
<td>3 (0.4)</td>
</tr>
<tr>
<td>Acute respiratory failure</td>
<td>1 (0.1)</td>
</tr>
<tr>
<td>Treated with epinephrine</td>
<td>50 (6)</td>
</tr>
<tr>
<td>Costs of index ED event in US $, mean ± SD</td>
<td>1,787 ± 2,353</td>
</tr>
<tr>
<td><strong>Hospital course (n = 147)</strong></td>
<td></td>
</tr>
<tr>
<td>Cardiorespiratory failure</td>
<td>39 (27)</td>
</tr>
<tr>
<td>Hypotension</td>
<td>30 (20)</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Respiratory arrest</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Acute respiratory failure</td>
<td>7 (5)</td>
</tr>
<tr>
<td>Treated with cardiopulmonary interventions</td>
<td>6 (4)</td>
</tr>
<tr>
<td>ICU/CCU admission</td>
<td>73 (50)</td>
</tr>
<tr>
<td>Hospital length of stay, median (IQR), d</td>
<td>1 (1-3)</td>
</tr>
<tr>
<td><strong>Hospital disposition, No. (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>132 (90)</td>
</tr>
<tr>
<td>Other hospital or acute care</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Other</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Missing</td>
<td>10 (7)</td>
</tr>
<tr>
<td>Costs of index hospitalization, mean ± SD, US$</td>
<td>11,366 ± 23,856</td>
</tr>
</tbody>
</table>

Abbreviations: CCU, critical care unit; ED, emergency department; ICU, intensive care unit; IQR, interquartile range.
Outcomes of patients treated in the ED or Hospital for stinging insect anaphylaxis

<table>
<thead>
<tr>
<th>1-Year outcome</th>
<th>Finding (n = 954)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAI prescription filled within 1 year, No. (%)</td>
<td>655 (69)</td>
</tr>
<tr>
<td>Time to EAI prescription fill, median (IQR), d</td>
<td>1 (0–3)</td>
</tr>
<tr>
<td>Allergist/immunologist visit within 1 year, No. (%)</td>
<td>134 (14)</td>
</tr>
<tr>
<td>Time to first allergist/immunologist visit, median (IQR), d</td>
<td>34 (13–70)</td>
</tr>
<tr>
<td>ED visit or hospitalization for anaphylaxis within 1 year,</td>
<td>25 (3)</td>
</tr>
<tr>
<td>No. (%)</td>
<td></td>
</tr>
<tr>
<td>Time to ED visit or hospitalization, median (IQR), d</td>
<td>5 (1–209)</td>
</tr>
</tbody>
</table>

Abbreviations: EAI, epinephrine autoinjector; ED, emergency department; IQR, interquartile range.

Rudders Ann All Asthma Immunol 2013;111:199-204
Patients often don’t carry or use their EIA
Use Assessment of Self-Administered Epinephrine Among Food-Allergic Children and Pediatricians

• Methods.
  • The investigators enrolled 101 families of consecutive, food-allergic pediatric patients newly referred to their allergy practice but previously prescribed epinephrine and a sampling of pediatricians. Parents or teenage patients answered a structured questionnaire concerning use of self-injectable epinephrine and demonstrated the use of devices with which they were familiar. Demonstrations were scored in a standard manner.

• Results.
  • Self-injectable epinephrine was prescribed (mean of 2.7 years previously) primarily by pediatricians (n = 46) and allergists (n = 49).
  • Eighty-six percent of the families responded that they had the device with them “at all times,” but only 71% of this group had epinephrine at the visit.
    • Among those with the epinephrine, 10% had devices beyond the labeled expiration date.
    • Thus, only 55% of the 101 families had unexpired epinephrine on-hand at the time of the survey.
  • Only 32% of the participants correctly demonstrated the use of the device.

• *It should be noted that others have demonstrated carriage rates that are even more abysmal (25%)
  • DeMuth All Asthma Proc 2011;32:295-300

This study reported on the refill history of 14,677 patients in a large HMO who received an initial dispensing of EpiPen/Jr between 2000 and 2006.

A total of 6,776 (46%) refilled at least once.

Infants through children 12 years of age were more likely to receive a refill dispensing (63%) compared with teenagers and adults (40%).

Twenty-five percent of the patients who were in the cohort for 5 years or more refilled multiple times, with only 11% refilling at all expected refill times.

Kaplan Curr All asthma Rep 2011;11:65-70
Despite the Lack of Use, Death from Anaphylaxis is Rare

- Currently, anaphylaxis leads to 500–1,000 deaths per year (2.4 per million) in the United States, 20 deaths per year in the United Kingdom (0.33 per million), and 15 deaths per year in Australia (0.64 per million) (Clin Exp All 2011;41: 923–38).


- An estimated 24,000 people are killed by lightning strikes around the world each year (lightningsafety.noaa.gov).
Despite the Lack of Use, Death from Anaphylaxis is Rare

• Each day 9 Americans die from asthma. There are more than 3,300 deaths due to asthma each year. In addition, asthma is indicated as “contributing factor” for nearly 7,000 other deaths each year.

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- People with food allergy more likely to be murdered than to die from severe reaction
  
  - Based on data from 13 studies worldwide, researchers at Imperial College London calculated that for any person with a food allergy, the chance of dying from anaphylaxis in one year is 1.81 in a million. For children and young people aged 0-19, the risk is 3.25 in a million.
  
  - By comparison, in Europe the risk of being murdered is 11 in a million and of dying from accidental causes is 324 in a million over a year.
  
  Boyle http://www3.imperial.ac.uk
Voluntarily reported unintentional injections from epinephrine auto-injectors

• Methods
  • Investigators searched the databases of the American Association of Poison Control Centers and the FDA’s Safety Information and Adverse Event Report System for these incidents as reported by members of the public and by health care professionals.

• Results
  • From 1994 to 2007, a total of 15,190 unintentional injections from epinephrine auto-injectors were reported to US Poison Control Centers, 60% of them from 2003 to 2007.
  • Those unintentionally injected had a median age of 14 years (interquartile range, 8-35), 55% were female, and 85% were injected in a home or other residence.
  • Management was documented in only 4101 cases (27%), of whom 53% were observed without intervention, 29% were treated, 13% were neither held for observation nor treated, and 4% refused treatment.
  • Forty percent of these occurred during attempts to treat allergic reactions. Injuries resulting in permanent sequelae were rarely reported to either US Poison Control Centers or to MedWatch.
Maybe this is good, as AIE is not without Side Effects
Epi Side Effects

- **Incidence not known**
- Abnormal or decreased touch sensation
- Arm, back, or jaw pain
- Bleeding, blistering, burning, coldness, discoloration of the skin, feeling of pressure, hives, infection, inflammation, itching, lumps, numbness, pain, rash, redness, scarring, soreness, stinging, swelling, tenderness, tingling, ulceration, or warmth at the injection site
- Blurred vision
- Chest pain or discomfort
- Chest tightness or heaviness
- Dizziness
- Fainting
- Fast, irregular, pounding, or racing heartbeat or pulse
- Fear or nervousness
- Headache
- Nausea or vomiting
- Paleness of the skin
- Pounding in the ears
- Restlessness
- Shakiness in the legs, arms, hands, or feet
- Shortness of breath
- Slow or fast heartbeat
- Stroke
Finger Injection with High-Dose (1:1,000) Epinephrine: Does it Cause Finger Necrosis and Should it be Treated?

Accidental epinephrine injections have been estimated incidence of 1 per 50k units.


Twenty minutes after injection of 1 cm³ of pure 1:1,000 epinephrine into the little finger.

Same finger 6 h later
Epi injected in the Digit

- A careful review of the world literature from 1880 to 2000 revealed that there were 48 case reports of digital gangrene and necrosis following local epi in the digits

Cardiovascular Side Effects with Epi

- Cardiovascular side effects have included elevations in heart rate or blood pressure in up to 55% and arrhythmias in 3% to 17% (including fatal ventricular arrhythmias) when used to treat cardiac arrest. In smaller doses, epinephrine has caused peripheral coronary arterial vasodilation, but in larger doses, epinephrine has caused diffuse vasoconstriction. This has caused increased peripheral vascular resistance, which was important in patients with coronary artery disease (worsened myocardial ischemia/angina) or hypertension (risk of emergent hypertension/stroke). Dilated cardiomyopathy and acute left ventricular dysfunction have been associated with the use of epinephrine.

- Arrhythmias, including fatal ventricular fibrillation, have been reported in patients with underlying cardiac disease. Rapid rises in blood pressure have produced cerebral hemorrhage, particularly in elderly patients with cardiovascular disease. Angina may occur in patients with coronary artery disease.

- Epinephrine can induce hypokalemia with resultant T wave changes on the electrocardiogram.

- Rare cases of myocardial infarction have been associated with relatively small doses of epinephrine in patients at risk for coronary artery disease.

- Rare cases of cardiomyopathy have been associated with brief and chronic exposure to epinephrine (including inhaled epinephrine). Animal studies have shown that catecholamines can cause an influx of calcium into myocardial cells, which may cause myocardial injury, particularly during periods of epinephrine-induced coronary vasoconstriction. Limited animal data suggest that calcium antagonists may protect against the cardiotoxic effects of catecholamines by preventing the generation of plasma borne cytotoxic compounds, which are probably free radicals.

- Epinephrine may be more arrhythmogenic in some patients, such as patients with congenital long QT syndrome.
Epi is Not without Side Effects

• Pulmonary edema with rales, rhonchi, dyspnea, frothy or bloody sputum, and an atypical chest x-ray picture may occur after an epinephrine overdose. Pulmonary edema usually develops within 20 minutes. It is unclear whether this pulmonary edema is cardiogenic or acute lung injury.

• Gas gangrene after IM administration of epinephrine has been reported. Three cases of gas gangrene after IM injection of epinephrine have occurred subsequent to administration of the drug into either the buttock or thigh. Two cases have resulted in death and only one case had appropriate treatment with gas gangrene antiserum, steroids, and antibiotics that resulted in survival of the patient. It appears that clostridium organisms become deposited into muscle tissue during penetration of the skin and that the vasoconstrictor properties of adrenaline enhance the effects of the infection.

Epi is Not without Side Effects

• A case of acute myocardial infarction following accidental iatrogenic overdose by adrenaline injection is described in a male aged 55 years. This patient was given 1 mg of adrenaline due to anaphylactic symptoms. Afterwards he presented with angina pectoris, dyspnoea and ST-segment elevation in the ECG. Plasma TnT and CK-MB were raised. A coronary angiography revealed a 66% stenosis of RCA. This patient had an asymptomatic RCA stenosis that probably became symptomatic due to coronary artery spasm related to adrenaline injection and thereby presented symptoms and signs of acute myocardial infarction.


• A case of a 30-year-old man who developed a myocardial infarction after self-administering an Epi-Pen for an episode of idiopathic anaphylaxis is reported. The patient had numerous risk factors for coronary artery disease, and it was suspected that epinephrine-induced coronary spasm caused the infarct. The Epi-Pen Junior may be indicated in such adults with numerous risk factors for coronary artery disease who are at risk for recurrent anaphylaxis.

  Saff R et al; Ann Allergy 70 (5): 396-8 (1993)
Epi is Not without Side Effects

• This case describes a 29-year-old woman who presented with an acute severe anaphylactic reaction to penicillin. In addition to other medications administered in the emergency department, she received 0.1 mg intravenously of 1:10 000 epinephrine, after which she immediately developed severe chest pain. Her ECG showed ST elevations consistent with an anterior myocardial infarction, and her serum troponin level was elevated. A CT angiogram showed no signs of coronary artery disease or abnormal anatomy.


• Myocardial infarction is a previously unreported complication of treatment with racemic epinephrine that is used commonly in the emergency department for severe respiratory distress in bronchiolitis or croup syndrome. We describe a pediatric patient who presented with the croup syndrome and severe respiratory distress that required multiple doses of nebulized racemic epinephrine in the emergency department. The patient developed ventricular tachycardia and mild chest discomfort during one treatment, which resolved spontaneously on discontinuation of the nebulization. Persistently abnormal electrocardiograms and elevated creatine phosphokinase MB isoenzyme (CPK-MB) levels suggested a myocardial infarction had occurred. Subsequent echocardiography, cardiac catheterization, and angiography revealed an anatomically normal heart with normal coronary circulation; however, a stress nuclear study showed a small myocardial infarct. The significance of this previously unreported complication of racemic epinephrine is discussed, along with recommendations for proper use in the emergency department.

Present Needles are Not Even Long Enough
Adequacy of the epinephrine autoinjector needle length in delivering epinephrine to the intramuscular tissues

- **Objective:**
  - To investigate whether EpiPen autoinjector, with a needle length of 1.43 cm, is sufficient for intramuscular delivery of epinephrine in men and women.

- **Methods:**
  - The distance from skin to muscle in the anterolateral aspect of the thigh was measured in 50 men and 50 women who had undergone computed tomography of the thighs for other medical reasons.
  - For each individual, body mass was also calculated, and the individuals were classified as underweight (BMI, <18.5), normal (BMI, 18.5-24.9), overweight (BMI, 25.0-29.9), and obese (BMI, >=30.0) using standard definition.

- **Results:**
  - In the study participants the mean ± SD distance from skin to muscle was 0.66 ± 0.47 cm for men and 1.48 ± 0.72 cm for women (P < .001).
  - One man (obese at a BMI of 42.2) and 21 women (11 obese with a mean BMI of 35.2, 6 overweight with a mean BMI of 30.1, and 4 normal with a mean BMI of 24.5) had a greater distance from skin to muscle than the EpiPen needle length of 1.43 cm.

- **Conclusion:**
  - The distance from skin to muscle for the anterolateral aspect of the thigh is higher in women compared with men. This difference suggests that EpiPen may not deliver epinephrine to the intramuscular tissue in many women.

  *Song Ann All Asthma Immunol 2005;94: 539–542*
Figure 1. Coronal computed tomograms of the right thigh. Distance from the skin surface to muscle was measured with a digital ruler. In this example, the distance to muscle was 1.3 cm.
Figure 2. Scatterplot of the distance to muscle vs body mass index for men and women. Dashed vertical lines are drawn to identify the body mass index categories. The horizontal line indicates the length of the epinephrine autoinjector needle length of 1.43 cm. Individuals above the 1.43-cm line would most likely receive subcutaneous epinephrine.

Song Ann All Asthma Immunol 2005;94: 539–542
Epinephrine Auto-injectors: Is Needle Length Adequate for Delivery of Epinephrine Intramuscularly?

The objective of this study was to determine if the needle length on epinephrine auto-injectors is adequate to deliver epinephrine intramuscularly in children.

• METHODS:
  • Patients between the ages of 1 and 12 years who presented to a children’s hospital were enrolled in the study.
  • Ultrasound was used to determine the depth from the skin to the vastus lateralis muscle.
  • The patient’s body mass index was recorded.
  • The data were analyzed using simple descriptive statistics, and logistic regression was used to identify variables that might predict whether or not the needle length was exceeded.

Stecher Pediatrics 2009;124:65–70
Epinephrine Auto-injectors: Is Needle Length Adequate for Delivery of Epinephrine Intramuscularly?

• RESULTS:
  • A total of 256 children were enrolled. Of these, 158 children weighed less than 30 kilograms and would be prescribed the 0.15mg epinephrine auto-injector.
  • Nineteen of these children (12%) had a skin to muscle surface distance of >1/2" and would not receive epinephrine intramuscularly from current auto-injectors.
  • There were 98 children weighing ≥30 kilograms who would receive the 0.3 mg epinephrine auto-injector.
  • Of these 98 children, a total of 29 (30%) had a skin to muscle surface distance of >5/8" and would not receive epinephrine intramuscularly.

• CONCLUSION:
  • The needle on epinephrine auto-injectors is not long enough to reach the muscle in a significant number of children. Increasing the needle length on the auto-injectors would increase the likelihood that more children receive epinephrine by the recommended intramuscular route.

Stecher Pediatrics 2009;124:65–70
FIGURE 2
Scatter plot of depth to muscle from skin surface vs BMI (30-kg group). The vertical line represents the length of the needle (15.8 mm).
Delivery depth of epinephrine by auto-injector into the subcutaneous tissue of pig

Methods

• As obesity continues to rise, there is concern that the needle length of the auto-injector may not be long enough for intramuscular delivery.

• Therefore, this study was designed to investigate whether the EpiPen can propel epinephrine beyond the length of the needle in a cadaveric pig model.

• The EpiPen was disassembled (spring-loaded canister was left intact), and 0.1 mL of the volume was removed by inserting a needle into the syringe just lateral to the rubber plunger.

• Next, 0.1 mL methylene blue was added as a color tracer, and the auto-injector was reassembled.

• In this study, cadaver pig legs were used to measure delivery depth of epinephrine.
  • Presently, no body mass index is available for the pig in the veterinary literature.
  • Therefore, inter-pig comparisons were made based on the mid-thigh circumference distance.

• The auto-injector was then placed on the thigh, and pressure was applied until the auto-injector triggered.

• Afterwards, an incision was made down to the site of injection of each thigh, and the subcutaneous tissue depth, SCTD (distance from the surface of the skin to the methylene blue/epinephrine mixture), was measured and recorded and compared with the mid-thigh circumference for each of the 24 pig legs.

Song Annals Ann Allergy Asthma Immunol 2013;111: 138e148
Delivery depth of epinephrine by auto-injector into the subcutaneous tissue of pig

• Results
  • the auto-injector’s needle length of 1.43 cm is adequate to deliver epinephrine to the intramuscular tissues in all pigs studied.
  • All of the epinephrine injections were delivered beyond the subcutaneous fat into the intramuscular space.
  • All of the injections had SCTD greater than 1.43 cm in the pig model with a mean SCTD of 2.78 cm which is 94.4% beyond the autoinjector’s needle length.
  • The force that allows the delivery of epinephrine beyond the subcutaneous fat and into the intramuscular tissue is most likely the combination of both the compression of the underlying tissues applied by the patient (2-8 lbs of pressure) and the spring-loaded propulsion of the auto-injector
  • This suggests that some obese patients may be receiving the medication in the intramuscular space.

Song Annals Ann Allergy Asthma Immunol 2013;111: 138e148
Hind limb of the pig. Two-step method for measurement of the mid-thigh circumference.
Scatter plot of subcutaneous tissue depth vs mid-thigh circumference.

The horizontal line indicates the epinephrine auto-injector needle length of 1.43 cm. Dots represent the correlation between the 2, and the size of the dot represents collocation of data points.

*Song Annals Ann Allergy Asthma Immunol 2013;111: 138e148*