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TRAUMA rounds

Management of Lower Extremity Arterial Trauma: The UPMC Experience

by **Nathan L. Liang, MD, and Rabih A. Chaer, MD, MSc**

History of Lower Extremity Vascular Trauma

The majority of current knowledge of extremity arterial trauma has been gained from military experiences. The origins of modern extremity trauma management are rooted in World War II with the recognition of the importance of popliteal segment injuries. Advances continued with the development of bypass surgery, and most recently with the increasing use of short-term shunting for stabilization and evacuation. These experiences, though beneficial, are not broadly generalizable to civilian injury, since even injuries seen at a Level I trauma center differ greatly from those in combat situations. The incidence of leg arterial trauma in the general population is thought to be less than 1% of injured patients.

Current Management

When revascularization is required for extremity arterial injury, unless the injury is suitable for primary repair, bypass grafting is usually required. Endovascular techniques for revascularization have been reported but are not common; in general practice, these are utilized only for coil embolization of traumatic pseudoaneurysms.

Surgeons have long recognized the importance of the level of arterial injury. The popliteal artery serves as the lone major arterial conduit between the thigh and the lower leg, and interruption of blood flow from an injury can quickly lead to irreversible ischemia due to limited collateral blood flow.

Other arterial segments of the leg seem to fare somewhat better; traditionally, injuries to upper leg vessels, such as the common or superficial femoral arteries, are repaired with high levels of success. The three tibial calf vessels provide redundancy, and the practice of not revascularizing tibial vessels as long as one remains patent has been shown to be acceptable in some observational studies.

The usual goal in treating arterial vascular injury is to prevent irreversible ischemia leading to a delayed amputation. Rarely, a patient has sustained such severe extremity damage that an amputation is the initial primary operation.

Management of Lower Extremity Arterial Trauma *(Continued from Page 1)*

Several scoring systems for the mangled extremity have been developed to assist in initial management. The most well-known is the Mangled Extremity Severity Score (MESS). Although an increase in any score correlates with an increased risk of delayed amputation in almost all observational studies, researchers have been unable to define clear thresholds at which primary amputation is immediately advantageous over limb salvage.

The UPMC Experience

Over the past 10 years, 149 patients have presented with traumatic lower extremity arterial injury to the UPMC Trauma Care System at UPMC Presbyterian. The majority was male (86%), with an average age of 33 years. More than half (54%) were low-energy penetrating wounds from handgun projectiles, and 29% resulted from low-to-moderate speed motor vehicle collisions, with the remaining 17% from high-energy blunt trauma (motorcycle injuries, vehicle vs. pedestrian, or high-speed motor vehicle collisions).

There were 50 popliteal (34%), 45 femoral/superficial femoral (30%), and 54 tibial vessel (36%) injuries. Associated injuries of vital structures were common: 59% of all injuries were accompanied by fracture or knee dislocation, 28% by nerve injury, and 11% by venous injury.

Seven patients had injuries deemed too severe for salvage and required a primary amputation. The remaining 142 patients underwent attempted limb salvage, and of those, 24 (17%) eventually required a delayed amputation. Among the delayed amputations, 13 (54%) were for irreversible ischemia despite revascularization; the rest were for either insufficient soft tissue coverage or irreparable joint or bone instability (7, 29%) or intractable pain/nonfunctional limb (4, 17%).

Femoral and Superficial Femoral Artery

The majority of femoral and superficial femoral injuries were well tolerated. Due to the location of the femoral vessels within the muscular thigh and groin, injury via a blunt mechanism would require a very high-energy impact. As a result, most injuries were due to low-energy penetrating injuries (handgun projectiles or stabbing); only seven (16%) injuries were due to blunt trauma. Two (4%) patients, both presenting after motorcycle accidents, underwent delayed amputation.

Popliteal Artery

All seven primary amputations were in the popliteal injury group. The majority underwent a revascularization operation (78%, 39 total: 36 bypass grafts and three primary repair). This group also had the worst outcomes, with a quarter of patients requiring delayed amputation (11, 26%), consistent with current rates in the literature. More than half underwent amputation for residual ischemia persisting despite adequate revascularization (6, 55%). Patients undergoing delayed amputation in this group were more

Figure 1. Mangled calf with all bones and vessels transected.

likely to have higher injury severity scores (ISS, 15.45±12.18 vs. 8.91±4.64, p=0.01) and higher MESS scores (6.73±1.56 vs. 4.59±1.95, p=0.002) than non-amputees. Mechanism of injury, length of ischemic time, and presence of traditional negative prognostic co-injuries such as nerve and venous injuries were not different in those requiring amputation.

Peroneal, Posterior, and Anterior Tibial Artery

Tibial artery injuries made up the largest group and were also the most variable. Injury profiles ranged from a single occluded artery due to ankle fracture, to high-speed injuries with massive musculoskeletal damage and disruption of all three vessels. Few patients in this group underwent operative revascularization (12, 22%) with primary repair or bypass with saphenous vein graft.

The outcomes in this group support the premise that vascular injuries in the calf may be less responsible for progression to delayed amputation than degree of soft tissue damage. Eleven patients underwent delayed amputation, mostly due to unreconstructable soft tissue injuries (7, 63%). Patients who presented with multiple tibial vessel injuries had higher rates of amputation (45% vs. 15% single tibial, p=0.04). Degree of soft tissue damage was not analyzed in this cohort, but it can be inferred to be greater in those with more than one tibial injury due to the anatomic distribution of the arteries in the calf.

Figure 2. Above-knee popliteal exposure after knee dislocation and popliteal artery occlusion.

Conclusions

The management of lower extremity arterial trauma in civilian patients has improved greatly in the modern era of medicine, but since the late 1990s, amputation rates have remained fairly constant, especially among those with popliteal artery injury. Individualized assessment and treatment of the trauma patient by an expert, multidisciplinary team, such as that within the UPMC Trauma Care System, remains the best option for increasing the chance of limb salvage.

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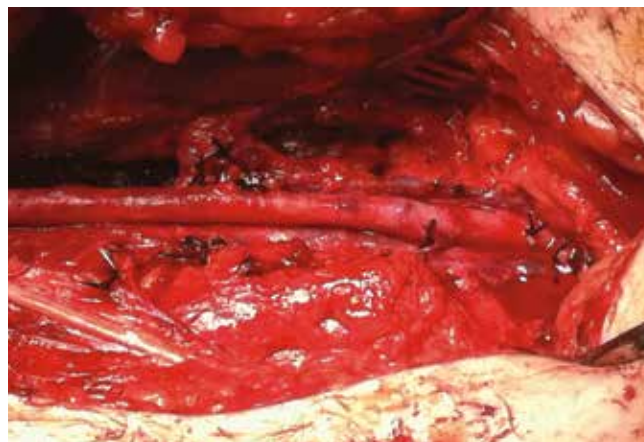
Figure 3. Above-knee popliteal artery after excision and saphenous interposition of injured segment.

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Update on ARDS Management

by Chenell Donadee, MD, and Scott Gunn, MD

Introduction

Acute respiratory distress syndrome (ARDS) is an inflammatory response in the lungs and is a life-threatening complication of trauma. ARDS is defined as bilateral lung opacities that occur within one week of insult, associated with a PaO2:FiO2 ratio ≤300, and not fully explained by cardiac failure or pulmonary edema. It is estimated that there are 190,600 cases of ARDS every year in the U. S., and it affects 20% of mechanically ventilated patients. ARDS associated mortality ranges from 27% to 45% depending on the severity of the disease. Common causes in patients with trauma include pneumonia, pulmonary contusion, transfusion-related lung injury, aspiration pneumonitis, and the trauma itself.

In recent years, new evidence has emerged regarding therapeutic interventions that reduce mortality for patients with ARDS. These therapies are not exclusive and can be deployed either individually, in a staged manner, or in combination. The strongest evidence for improved mortality exists for low tidal volume ventilation, prone position ventilation, neuromuscular blockade, and extracorporeal

A Change in Posture

by Francis X. Guyette, MD, MPH

There are roughly 9,000 spinal cord injuries yearly resulting in devastating morbidity and mortality. In the 1960s, delayed recognition of spinal injury resulting in paralysis was a key concern for those developing EMS systems. Following Farrington's 1967 paper "Death in a Ditch," which describes a patient with neck pain who is pulled from a car wreck only to suffer permanent paralysis, providers struggled to find ways to protect those with neck injuries.[1] As late as 1983, Podolsky, et al. in the Journal of Trauma state that 40% of cervical spine injuries result in neurologic deficits, and up 25% of these are caused by "improper handling during transport."[2]

The response to this desperate situation was to recommend full spinal immobilization, including a backboard and rigid cervical collar, for patients with suspected spinal injury. Over the next 30 years this practice has been expanded to include any patient with a mechanism of injury that could potentially result in a neck injury. Furthermore, the last three decades have produced little evidence that the backboard provides any benefit, and an increasing body of evidence has suggested harms ranging from localized pain, pressure sores, sacral hypoxia, and respiratory compromise.[3,4,5] The purported mechanism by which delayed spinal injury occurs has also been questioned as evidence mounts implicating local tissue hypoxia, cord hypoperfusion, cord compression, and edema as key factors in delayed paralysis.

A comparison of spinal injuries between New Mexico (spinal immobilization as standard of care) and Malaysia (no spinal immobilization) conducted by Hauswald et al. demonstrated no difference in outcomes.[6] A 2010 analysis of the National Trauma Data Bank by Haut revealed that patients with penetrating injury had worse outcomes when immobilized.[7] In 2012, Hauswald suggested a "Re-conceptualization of Acute Spinal Care."[8] He espoused that injury is caused by energy, not motion. He notes that the energies involved at the time of injury are great and those during subsequent care and movement are low. He also suggests that most injuries are biomechanically stable and that the tissues near the injured spine are generally resistant to movement. A subsequent study from Ireland has suggested that the best method for minimizing spinal motion is self-extrication.

Fortunately there is evidence for selective use of spinal immobilization, and in particular backboard use. Many of these are based on criteria derived from the NEXUS study, which was designed to limit imaging, not immobilization. Domeier further modified the criteria for spinal immobilization.[9] Based on these data, the National Association of EMS Physicians and the American College of Surgeons Committee On Trauma developed a position statement in 2013, which recommended selective use of spinal immobilization.[10] American College of Emergency Physicians (ACEP) has approved a policy statement in 2015, which is similar, noting that backboards should be used selectively in EMS based on evidence and should not interfere with critical interventions such as airway management.[11]

ACEP states that immobilization should be considered for patients with blunt mechanisms and any of the following:

1. Altered mental status
2. Intoxication
3. Neurologic deficit
4. Spine pain or tenderness
5. Patients with painful distracting injury (e.g., extremity fracture)

The policy indicates that backboards should not be used as a therapeutic intervention or as a precautionary measure for inter-facility transfers. It also states that backboards should not be used on patients with penetrating injury.
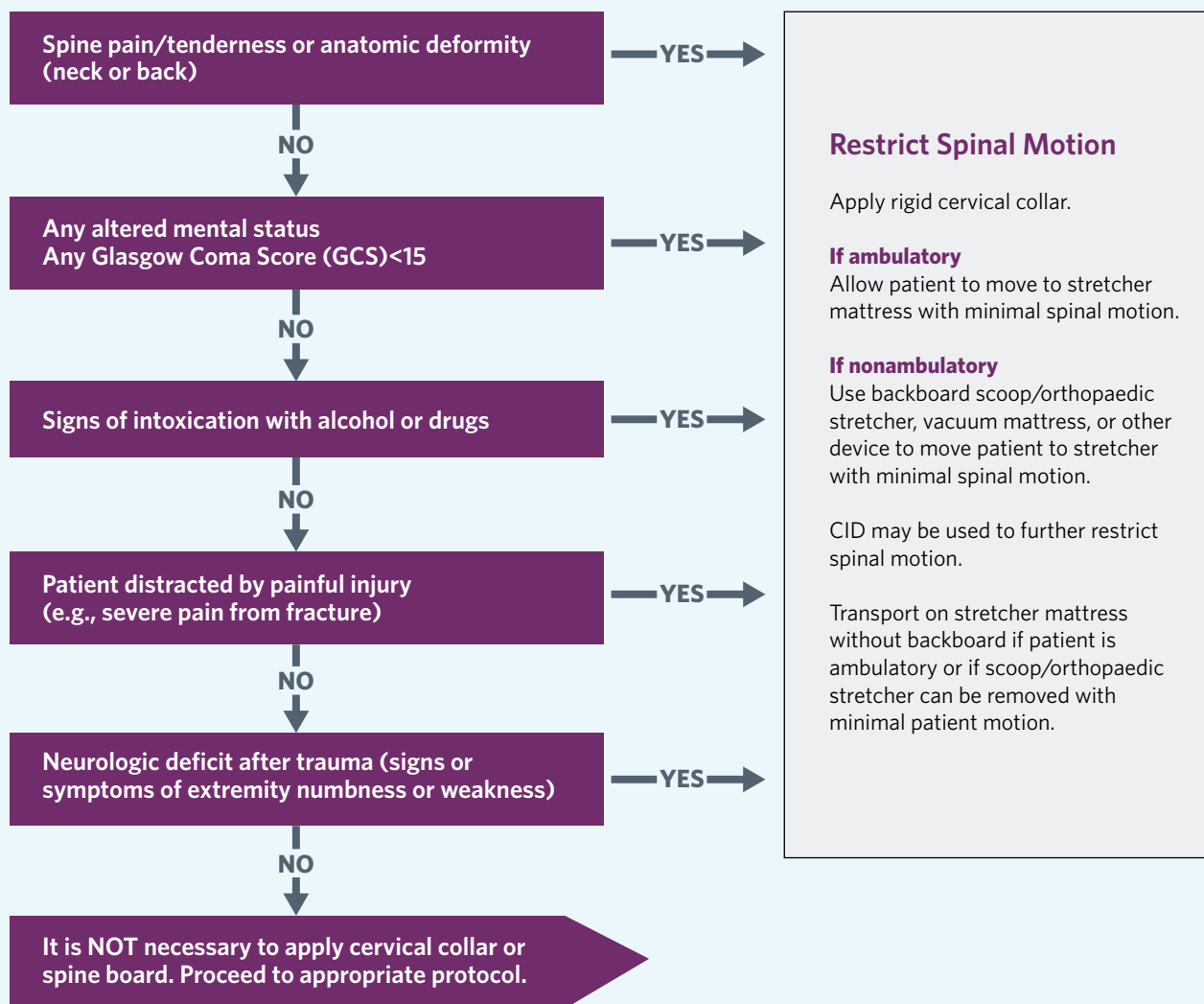
As a result of this guidance, the Pennsylvania Department of Health has changed their protocols with respect to prehospital immobilization (Figure 1). Patients who meet none of the criteria will not have spinal immobilization applied. Those that meet the criteria will have a cervical collar placed, but a backboard will not be required. The patient may be safely immobilized using a scoop stretcher, vacuum splint, or an ambulance stretcher. Movement from these devices to the trauma bed requires caution to minimize the energy imparted to the patient's spine and can be accomplished with a slider board and a log roll.

These new protocols give us the opportunity to use spinal immobilization techniques judiciously. The following points should be kept in mind:

1. Assess and document the five spinal immobilization criteria on all patients with a mechanism of injury.
2. Immobilize only those patients that meet the criteria for immobilization.
3. Do not immobilize patients with penetrating injury that do not have a focal neuro deficit.
4. Do not backboard ambulatory people.
5. Do not fight patients to achieve immobilization.
6. Backboards may still be useful as extrication devices and as rigid boards for performing CPR.
7. Consider using a slider or similar device to transfer the patient.
8. Please do not provide negative feedback to EMS for correct application of the new protocols.

Figure 1. Prehospital immobilization protocol from the Pennsylvania Department of Health.

All Patients: Initial patient contact — Protocol #201 Mechanism or signs of blunt trauma

Spine pain/tenderness or anatomic deformity (neck or back) → YES	**Restrict Spinal Motion** Apply rigid cervical collar. **If ambulatory** Allow patient to move to stretcher mattress with minimal spinal motion. **If nonambulatory** Use backboard scoop/orthopaedic stretcher, vacuum mattress, or other device to move patient to stretcher with minimal spinal motion. CID may be used to further restrict spinal motion. Transport on stretcher mattress without backboard if patient is ambulatory or if scoop/orthopaedic stretcher can be removed with minimal patient motion.

NO ↓

Any altered mental status Any Glasgow Coma Score (GCS)<15 → YES

NO ↓

Signs of intoxication with alcohol or drugs → YES

NO ↓

Patient distracted by painful injury (e.g., severe pain from fracture) → YES

NO ↓

Neurologic deficit after trauma (signs or symptoms of extremity numbness or weakness) → YES

NO ↓

It is NOT necessary to apply cervical collar or spine board. Proceed to appropriate protocol.

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membrane oxygenation. Although other therapies have been investigated (such as "higher" versus "lower" PEEP, pulmonary vasodilators, and high-frequency oscillation ventilation), none of these interventions has shown a mortality benefit.
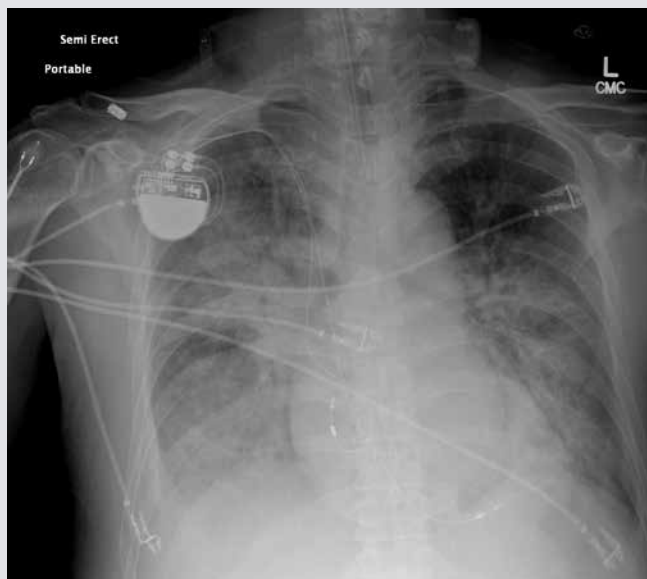
Low Tidal Volume Ventilation

Low tidal volume ventilation is the standard of care for patients with ARDS. After multiple preclinical investigations and small clinical trials, the ARDSnet investigators published a multi-center randomized trial of 861 patients with ARDS, which showed improved mortality at 180 days in patients who received a tidal volume of 6mL/kg predicted body weight (PBW) vs. 12mL/kg PBW (31.0% vs. 39.8%, P=0.007). Additionally, patients in the low tidal volume group had more days off the ventilator (12±11 vs. 10±11, P=0.007) and more days without nonpulmonary organ failure (P= 0.006).

Since publication of this landmark trial in 2000, other studies have found improvement in patient outcomes — even for patients with normal lungs. An intraoperative trial of low tidal volume ventilation in patients undergoing elective surgery found a composite endpoint of major pulmonary and extrapulmonary complications occurred less frequently in the low tidal volume group within the first seven days (10.5% vs. 27.5%, P=0.001). Moreover, 5% of patients in the low tidal volume group vs. 17% of patients in the high tidal volume group required reintubation or noninvasive ventilation in the first seven postoperative days. Given the strength of the evidence, our current practice in the UPMC Department of Critical Care Medicine is to place all mechanically ventilated patients on low tidal volume ventilation.

Prone Positioning

A recent multicenter, prospective, randomized controlled trial showed improved 28- and 90-day mortality with prone positioning for at least 16 hours a day in severe ARDS (defined as a PaO_2:FiO_2 of < 150 on 60% FiO_2 and PEEP ≥ 5). Twenty-eight-day mortality was 16% in the prone group and 32.8% in the supine group (P< 0.001) with a hazard ratio for death in the prone group of 0.39. Ninety-day mortality was 23.6% in the prone group vs 41.0% in the supine group (P< 0.001). The prone group also had statistically significant improvement in ventilator-free days at both 28 days and 90 days. Rate of successful extubation at 90 days was higher in the prone group. Incidence of complications did not differ between the groups, except for incidence of cardiac arrest, which was higher in the supine group. This is a well-conducted multicenter trial with a homogenous group of patients with severe ARDS. All patients received low tidal volume ventilation and standard ventilator weaning. Prone position ventilation showed a 51% relative risk reduction in mortality at 28 days with a number needed to treat of six. This mortality reduction persisted at 90 days.

Chest x-ray of intubated patient with ARDS showing diffuse bilateral multifocal fluffy airspace disease.

There are some practicalities that must be considered when prone positioning a patient. It is important to have adequate staff present when changing a patient's position from prone to supine or vice versa. The video that accompanies the PROSEVA trial demonstrates a method for positioning a patient and can be found at the web address at the end of this article. It is important to pay special attention to potential for skin breakdown, and our group recommends repositioning of the patient every two hours.

Neuromuscular Blockade

A multicenter, double-blind trial of 340 patients showed improved 28-day mortality with 48 hours of neuromuscular blockade (NMB) with cisatracurium vs. placebo in patients with severe ARDS. Twenty-eight-day mortality was 23.7% with cisatracurium vs 33.3% with placebo (P=0.05) and 90-day mortality was 30.8% vs 44.6% (P=0.04). Importantly, incidence of ICU-acquired weakness was not different between the groups. The cisatracurium group had more ventilator-free days at 28 and 90 days, more days free of organ failure (other than lung) in the first 28 days, and spent more days outside the ICU between days 1 and 90. NMBs are safe and may improve mortality, decrease duration of mechanical ventilation, and decrease complications related to barotrauma. Although this is a relatively small trial, the absence of significant short-term adverse effects and the potential to improve mortality suggest NMBs are beneficial in severe ARDS. A new larger multicenter trial to re-examine the safety and efficacy of NMBs is planned in the near future.

Extracorporeal Membrane Oxygenation (ECMO)

The Conventional Ventilatory Support Versus ECMO for Severe Adult Respiratory Failure (CESAR) trial enrolled 180 patients, who

were randomized to transfer to an ECMO center (n = 90 patients) or to receive conventional therapy (n = 90). Interestingly, only 68 (75%) patients in the ECMO group actually received ECMO. Sixty-three percent of patients allocated to consideration for treatment by ECMO survived to six months without disability, compared with 47% of those allocated to conventional therapy (relative risk 0.69; 95% CI 0.05-0.97, p = 0.03). Patients randomized to ECMO were all transferred to high-volume centers. In other words, this study shows that ECMO referral is beneficial, but doesn't answer the question about which patients should receive ECMO. Unfortunately, there is was no protocolized management of patients either in the ECMO or conventional group.

Conclusion

ARDS can be caused by many diagnoses commonly associated with trauma and carries with it a high mortality rate. Fortunately there are now four major interventions that can decrease mortality for these patients. These interventions can and should be used in combination to provide the best outcomes for patients.

The PROSEVA trial prone positioning video can be found at **http://www.nejm.org/doi/full/10.1056/NEJMoa1214103**.

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Advanced Trauma Life Support at UPMC Hamot	Full Course: November 5-6, 2015 Recertification: November 6, 2015	**Sarah Mattocks** mattockssl@upmc.edu, 814-877-5687
Advanced Trauma Life Support at UPMC Presbyterian	Full Course: November 9-10, 2015 Recertification: November 10, 2015	**Jennifer Maley** maleyjl@upmc.edu, 412-647-8115
Advanced Trauma Life Support at UPMC Presbyterian	Full Course: December 7-8, 2015 Recertification: December 8, 2015	**Jennifer Maley** maleyjl@upmc.edu, 412-647-8115

INTRODUCING EMS VIRTUAL DRIVE

UPMC has partnered with EMSI (Emergency Medical Service Institute) to bring a sophisticated ambulance simulator training system to EMS providers in the region. EMS Virtual Drive, the only mobile interactive drivers' simulation center in the state, debuted during the opening session at EMS Update 2015.

First created by Duran Precision, the simulation training is what long haul truckers and pilots have used for years. Now the $310,000 rig, which has been funded jointly by the state

EMSI members and UPMC, is coming to 135 ambulance services in western Pennsylvania. "We can simulate day time operations, night time, snow, rain, all in the comfort of our mobile simulation lab," says Brian Shaw, deputy director, EMSI. With 600,000 calls a year statewide and thousands of drivers operating ambulances, around one ambulance a day crashes in Pennsylvania. Shaw says, "The goal is to improve driver safety and provide cost-effective training to EMS providers across the region."

To watch a video on EMS Virtual Drive, visit **UPMC.com/TraumaRounds**.

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