Thank you very much, Fernando. It's also a pleasure for me to be here this morning, and to follow Dr. Graf. One of the things that I was concerned about when I first came to Texas Children's five years ago was the lack of a transport service, and I think that the ICU team has done an outstanding job and have absolute first rate inter-hospital transport service available now. And it's made it much better for us to care for patients with surgical problems, and in particular trauma patients.

I have two or three messages that I want to leave with you today. I'm not going to spend too much time talking about the details of the surgical management of pediatric trauma care because I don't think it's really important to you. But I want to give you some idea about how serious the problem is in a public health sense. I’d like to give you some thoughts, or to plant some ideas in your mind, about what we as individual physicians who have practices and patients that we care for, and community relationships, can do about it. And then I’m going to give you an overview of the typical management of a major trauma patient in terms of the phases of care that they go through while they’re in the hospital.
This is Dr. Maxson here. You can see that it would take more than a good makeup artist to make me look like him. But Todd is doing a locum in Saudi Arabia now, in a fairly big hospital where they don’t have a pediatric surgeon; and it’s part of our mission to help out in other areas of the world where we can provide our services. This is the group of Baylor pediatric surgeons. I thought you might be interested in meeting them if you haven’t already. This is, from left to right - Jed Nuchtern, who is an expert in surgical oncology. Paul Minifee, Darrell Cass, and Yinka Olutoye are the two youngest members of our group who have initiated a fetal surgery program at Texas Children’s Hospital. Most of you probably know Mary Brandt, who has been in practice in our group for more than ten years now and has built an outstanding practice with a special interest in endocrine surgery. And Todd is a trauma specialist, and is in charge of the trauma program that’s currently at Ben Taub. Well, I don’t know what comes to your mind when you think of trauma patients, but having talked to hospital administrators and physicians at Ben Taub and at Texas Children’s, the first things that people think about are drunk drivers, outlaws, drug busts gone bad. And of course those things may characterize the adult trauma population, but I think we need to remember that pediatric trauma patients are almost always innocent victims of an environmental situation over which they have no control. It’s true that children from lower socioeconomic classes are at greater risk of trauma. They are at greater risk for many of the diseases that we treat. But by and large the kids are innocent victims and are otherwise perfectly healthy, normal people.
Statistically Speaking

- 22 million children seek medical care yearly
- 22,000 die annually
- Most common cause of childhood mortality from ages 1 to 14 years
- Causes of fatal injury vary with age
- Death rates are falling

Just to give you some statistics about how big a problem this is, approximately 22 million seek medical care for injuries in the United States every year. About 22,000 die. To give you some perspective, there are about 400 new cases of Wilms tumor in the United States a year, and almost all of those children survive. So when you think about 22,000 deaths, you realize, or you must come to the conclusion that it’s a big problem. It, in fact, is the leading cause of death in children after the neonatal period.
And this pie chart illustrates that fact. This is 46%, approximately, of all deaths in these age groups in the U.S. are caused by trauma. So if you're an individual practitioner, you are much more likely to lose a patient from your practice to an injury than to any other illness.
Well, what can we do? And I guess the most fundamental thing I would like to say is that we need to provide a safe environment for our children. It’s a good overarching principle that we use. I had a trip once to Sweden to visit – I think it was in 1989 – a world conference on injury control. And they actually have towns and cities in Sweden that are designed so children can live their whole life without interacting with motor vehicle traffic. The pathways from every home in the community to the schools and the other places that children have to go to do not intersect with streets. And it’s a very, very safe environment. Now obviously where we live, this would be totally impossible, but it’s a nice concept.
Statistically Speaking

- Most common injury mechanisms: MVC and falls
- Highest mortality rates: MVC, drowning, fires and homicide
- Over 50% of fatalities involve head injuries

Now to get down to more specific details about what we can do, it’s important to look a little bit at the epidemiology of pediatric injuries, and what are the biggest problems. The most common mechanism has to do with motor vehicle crashes. These are occupants of cars that are involved in collisions, or pedestrians or bicyclists that are struck by motor vehicles, usually in public streets, although there is a particular problem of kids being run over in their own driveways, which is the classical scenario of a toddler accident. And it’s been statistically shown that it’s more likely to occur if the family owns a minivan or a SUV than if they own a conventional car. Drowning. Fires. Homicides. Obviously in the first year of life, in fact, the most common cause of injury death is child abuse. Drowning and fires are common in the preschool bracket and don’t seem to cause as many deaths in the school age children, although drowning becomes a problem again in adolescence when kids begin to get involved in drinking. It’s important to know that over 50% of the blunt trauma deaths that we see in the hospital are caused by closed head injuries, for which we have very little to offer surgically.
Another message I’d like to leave you with is that injury prevention works. The data now over the last 20 years since the first – or 25 years now – since the first seatbelt legislation in Tennessee, show that there’s been a tremendous reduction in the number of deaths to children involved in motor vehicle crashes when adjusted for exposure, that is, the number of miles traveled and that sort of thing. So, injury prevention has made a huge impact on the numbers of injuries and fatalities from injury across the country. And I think that primary care providers can play a key role in presenting information about injury control, making available information about injury control to their patients. And in fact you are in a position to do far more about reducing the fatalities to injury than we can as surgeons in the hospital. The first legislation about pediatric or child restraints and car seats came from an observation, or at least was partly based on an observation, that in a particular crash, the children in the car were more likely to die than the adults because of the fact that they were thrown around more and were therefore exposed to greater risk of injury.
Smoke detectors and fire extinguishers in the home are very important.
There’s very clear data, in fact, quite old data now, that bicycle helmets will reduce the risk of head injury associated with bicycling, and obviously that’s something that we need to promote.
Now I'd like to give you a little bit of an overview of the types of injuries that we see. Because the injuries occur in fairly predictable patterns based on mechanism and the child’s age. The commonest injury mechanism is what we call blunt trauma. These are the kinds of injuries that occur from falls, motor vehicle crashes, pedestrians struck by cars. The hardest area to deal with in terms of diagnostics is the intra-abdominal injuries because it’s very difficult to see inside the abdomen. You can see inside the head very well with CT scan, and in the chest with a plain chest x-ray. But if you think about the viscera in the abdomen as being in two main categories, solid organs and hollow viscera, the solid organs, the kidneys, the liver, and the spleen are exposed to injury and blunt trauma and cause bleeding. The hollow viscera, the gut, the bile duct, the bladder are exposed to injury and cause peritonitis, usually not bleeding. So the two things that you are looking for when evaluating a new trauma patient are signs of hypovolemia from bleeding, and signs of peritonitis from hollow viscera injury.
Snakebites are not that uncommon in this part of the country. Fortunately they are rarely fatal.
We see the odd impalement injury like this one. And these are almost all unique. They’re usually associated with falls of one type or another. This is a patient at Ben Taub. It occurred at school during a fall. The child survived nicely after it was removed in the operating room. The risk of these kinds of injuries – and actually cardiac injuries are more common from blunt mechanisms – is the development of pericardial tamponade and shock from that. Unfortunately we see some children with gunshot wounds.
The Acute Phase

- Transport
- Emergency Room Management
- Operating Room Management
- PICU
- Floor Care

Now the management of pediatric trauma patients falls into a few specific time periods. Transport is obviously very important, and I really have nothing to add to what Dr. Graf said, except to say that in an epidemiological sense, pediatric trauma patients are fairly thin on the ground. Ben Taub can fill its wards with the trauma patients from the streets of Houston, but pediatric trauma is distributed far and wide, and most patients are injured far from the nearest appropriate pediatric facility. So many, many trauma patients need to be transferred to a definite care facility. And we’ll talk a little bit about emergency room management, the OR, and the ICU, and the floor.
I again don’t have too much to add to what Dr. Graf said, but as far as I’m concerned, the two key things about inter-hospital transfer are controlling the airway and maintaining the child’s temperature. We tend to adjust our emergency rooms, our airplanes, to our own personal comfort, but children will become hypothermic if they are exposed in a 68 or 70 degree environment fairly rapidly. Usually in this context people mention C-spine control, so it’s conventional to put collars on these children and to place them on a backboard. I think the parents should be involved right from the beginning as much as possible and wherever possible one parent should be allowed to accompany the child during the transport. I think history – and I guess that term really means any information about the kid that can be passed along to the people at the trauma center – is extremely important. And the components of that are really, what was the mechanism? The details? What exactly happened when the child was injured? What has been done for the child in terms of how much fluid? What drugs? Etc. And what has been the physiological response to that? The child’s pulse, blood pressure, and level of consciousness as reflected in the Glasgow coma scale? And if you can provide that information, you’ll provide a tremendous service to the care of the patient. And obviously we like to include any printed material records and x-rays with the patient during the transport.
Now in the emergency room we need to again think of the injury patterns. If you see a lap belt mark across the abdomen, as I showed you in that earlier picture, think about hollow viscous injury because the small bowel is at risk in a lap belt injury. Remember to control the temperature in the emergency room. It’s very important. And I think that – this is obviously a bit self-serving, but I don’t think that it’s right to care for a major trauma patient, pediatric trauma patient, in a facility that doesn’t have dedicated pediatric expertise and equipment.
ER Care

- ABC’s – the management priorities same for all ages
- Airway – Most common cause of cardiac arrest is airway compromise
  - Shape & positioning
  - Emergency techniques

Now the priorities for care, ABCs. Airway, breathing, circulation, are the same for all ages. The airway is the most critical and the most common cause for cardiac arrest in the first few minutes after trauma. The emergency techniques that you need to know to care for a child in the emergency room are intubation of the airway, establishment of venous access, and placement of a chest tube. And if you can do those things, you can go a long way to lifesaving measures in the initial management of pediatric trauma patients. It’s very rare that a child has to be rushed right to the operating room.
We recommend needle cricothyroidotomy if it’s impossible to intubate the patient either because of trauma to the oropharynx or to the glottis or to the larynx itself. This is better than trying to do a tracheostomy or a tracheotomy or cricothyrotomy with a scalpel. A needle works. The patient will become hypercarbic quickly, but it’s one way to save a life.
I think it’s very important to remember that children may have cervical injuries that involve the spinal cord without an obvious radiologic abnormality. That’s what spinal cord injury without radiologic anomaly is referred to. And some series report approximately 50% of cervical spinal cord injuries are associated with a normal-looking chest x-ray. There is no fracture.
This is an example. This is a child with an atlanto-occipital dislocation. You can also see that there's some subluxation of the C1, C2 area. And the typical story in this patient, this type of patient, is apnea at the scene. There’s very little that will cause a child to completely stop breathing at the scene, except high cord or even brain stem injury. There’s no fracture. The things are all in line here. But there’s just too much space in the upper spinal cord. And young children – and it’s thought to be because their head is relatively large in comparison to their body size – are much more likely to get a high C-spine injury than a low C-spine injury, which is the typical kind of injury we see in teenagers and young adults.
Remember that as far as the breathing is concerned, children have very flexible ribs. They can have major intrathoracic injury, including pneumothorax and great vessel injury, cardiac injury, without any rib fractures. Which is different from adults. Adults who suffer significant intrathoracic injury almost always have rib fractures that can be detected clinically and easily detected radiologically. They have a very mobile mediastinum, so the physiological effects of a tension pneumothorax are much greater in young children than they are in adults. The circulation is the next priority. It’s often said, and I think it’s true, that children can maintain a reasonable blood pressure in the face of significant hypovolemia. What I do is feel the peripheral pulses at the wrist and the feet, and feel whether the extremities are warm and well perfused. If they’re cold, and the patient’s been injured, you can make a presumptive diagnosis of hypovolemia even though their systolic blood pressure may be normal.

I use a little rule of thumb that the body weight is two times the age plus eight, in kilograms. Two times age plus eight. And it works very well. And if you think a child is hypovolemic, you should give him 20 ml per kilo based on that calculation of isotonic fluid. Crystalloid or normal saline is fine and this can be repeated once at least. One of the big bugaboos of pediatric trauma is the development of cerebral edema. And I think it’s very important not to give free water to children. D5W, D5 quarter normal, D5 1/2 normal saline should never be used in the acute management of multiple trauma patients. You should only use isotonic crystalloids.
This is a child with a tension pneumothorax. The chest tube should be placed at the nipple level in the mid or anterior axillary line. Use about a 16-chest tube in a baby. About a 20-chest tube in a school age child. And a 28 in a teenager.
Interosseous infusion. I’m sure you’re all familiar with that. It’s the best way to do the initial resuscitation.
I think that what’s different about neonatal head injury and pediatric head trauma is that they get very few blood clots and they get a lot of cerebral edema. So I’ll reiterate, it’s very important not to give them a lot of free water. What you can do, and what I can do, to help a child like this, is to prevent them from becoming hypovolemic, or to treat hypovolemia, and to make sure they are well oxygenated and that their PCO2 is controlled in a normal range.
Now what do we do in the operating room? Well, it’s very important, again, to control temperature.
Twenty years ago we were castigated by the adult trauma surgeons for recommending non-operative management of solid organ injuries, which was pioneered by pediatric surgeons. And now it’s been universally adopted by trauma surgeons. So more than 90% of the kidney, liver, and splenic injuries can be treated non-operatively nowadays.
Occasionally they’ll bleed, and this is a typical ruptured spleen.
And this is what we do. We just cut off the bad part and leave the good part, and as long as you'll leave a third of the spleen intact, it will function normally.
This is a mesenteric tear that’s the typical kind of injury we see in seatbelt trauma.
The main role of the surgeon in the operating room is to stop the bleeding. We often just stop the bleeding and pack the patient’s abdomen without necessarily definitively treating them, particularly if they are acidotic, hypothermic, and coagulopathic, which this triad tends to go together in patients whose temperature has not been adequately controlled and who have not been adequately resuscitated before their transfer.
This is a gunshot wound. You can – this is an example of damage control. This child had a gunshot wound right through the hilum of the left lung. The lung was simply twisted. The attachments were taken down and the lung was twisted. It stopped all the bleeding. They went back the next day and took it out, and the child is perfectly fine now.
I think it’s very important for children with closed head injuries, actual skeletal fractures, burns, spinal cord injuries, to have early involvement of the Physical Medicine and Rehabilitation services, or whatever equivalent services you have in your hospital, and get them involved in terms of planning a rehabilitation program and starting it in the acute care facility, and carry it on through inpatient rehab and outpatient rehab.
I think I'll just say a little bit about the family. Major pediatric trauma is a huge insult to the family. It's psychological insult. Obviously, the parents' main role is to protect their children and the very fact that their child has been injured means that they have somehow failed. There are financial considerations. There's many aspects of the care that are not covered by insurance, plus there's often almost always a significant loss of income involved in situations where the child has to stay in the hospital for a long time.
And I think that child life services are very important in the intra-hospital care, but if you have a family that’s involved in a major pediatric trauma, I think it’s very important to help in any way you can to provide access to facilities in their local community for the psychological management and for the rehabilitation management.
And finally we need to particularly look out for the indications of child abuse and neglect. Two or three times a year we see a child with a small bowel tear or a liver rupture from blunt trauma caused by a direct assault, usually by a parent in immediate family. And whenever you suspect it, obviously it’s your legal obligation to notify the authorities.

And I guess I’ll stop there. Thank you very much.