

While quite a bit of trauma care is routine, involving simpler, single system injuries, a small subset of our patients sustains major, multi-system, and life-threatening ones. They require rapid access to skilled trauma professionals and advanced resources including imaging, operating rooms, and other procedures.

In most trauma centers, initial resuscitation takes place in a trauma resuscitation room in or near the ED. Some diagnostic imaging can be performed there, but more sophisticated studies may require a short (or longer) road trip. Operating rooms and other procedural areas are also usually more distant. And most importantly, each of these areas is designed for a single discipline. Diagnostic radiology has equipment, technicians, and radiologists available. Interventional radiology contains the specialized equipment needed for this more invasive procedure. Operating rooms are designed specifically for surgical procedures, and frequently contain equipment for a single surgical discipline.

But some of our patients require it all! Think about a patient who arrives after a major car crash. Blood pressures are soft, the pelvis is grossly unstable, FAST exam is positive, and there is bleeding from the vagina.

How do we prioritize? Where do we go first? How long will it take the interventional radiology team to arrive? Where's that external fixator equipment? Can we slip in a CT scan? Where's OB/GYN??

The solution is right under our nose! Many hospitals

TRAUMA CALENDAR OF EVENTS

TRAUMA, CRITICAL CARE & ACUTE CARE SURGERY
LOCATION: CAESAR'S PALACE, LAS VEGAS, NEVADA
APRIL 9 - 11, 2018

TRAUMA CENTER ASSOCIATION OF AMERICA ANNUAL CONFERENCE
LOCATION: HOTEL MONTELEONE CONFERENCE CENTER
NEW ORLEANS, LOUISIANA
APRIL 30 - MAY 4, 2018

have added so-called "hybrid ORs" to their operating suites in order to address the needs of their vascular and cardiovascular surgeons. This issue of the newsletter will explore retasking a hybrid OR for use in trauma care.

What Is A Hybrid OR?

A hybrid operating room is a special suite that allows advanced imaging to be carried out at the same time as one or more additional operative procedures. It's that simple. It contains specialized imaging equipment including fluoroscopy and infusion equipment for radiographic dye administration. Some also contain CT and/or MRI capabilities, although the shielding required for these makes them very rare. It is generally stocked with a variety of endovascular



devices and supplies. The usual anesthesia circuits are available, as are selected surgical packs, typically related to vascular and CV surgery.

These suites are typically large, and can easily accommodate multiple operating teams. **However, they are very expensive in a number of ways.**

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First, they take up a great deal of space. Many have the square footage of two or more standard operating rooms. **Initial construction costs are very high**, as are remodeling and maintenance costs. They can also tax the hospital engineering infrastructure, from electrical to plumbing to ventilation.

But if a hybrid room is available, it can deliver significant benefits to the hospital and to patient care. Intraoperative imaging can provide immediate quality assurance, and patients can undergo more complex procedures and enjoy a shorter length of stay.

Why Use A Hybrid OR For Trauma?

Trauma is a surgical disease, and specifically, a disease of bleeding. So many of the tools and processes we have developed for its management revolves around the control of hemorrhage.

When a major trauma patient arrives in the resuscitation room, the initial management involves rapid assessment and correction of life-threatening conditions. Recognition of bleeding is paramount. A rapid decision must be made as to the source of hemorrhage and the best way to control it.

Traditionally, bleeding control has been relegated to the operating room. Body cavities are opened as appropriate, and exsanguination is controlled by clamping, repairing, and/or suturing.

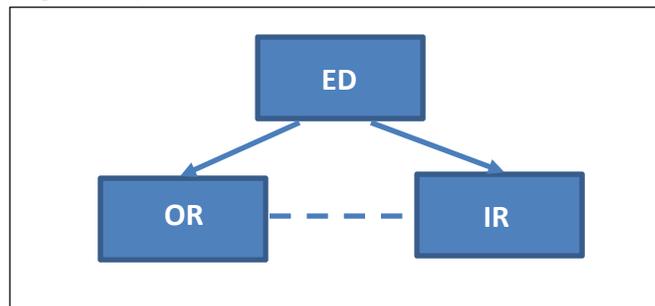
However, some body regions are much more challenging. The most notable is the pelvis, and specifically, the unstable pelvis. In the old days, after wrapping or applying an external fixator, the best we could do was to ligate the internal iliac arteries bilaterally and hope the bleeding would slow down *sufficiently* (it never really stopped) so that internal packing might have a chance.

As the use of interventional radiography grew in trauma, it became possible to noninvasively occlude the internal iliacs. And then, the radiologists became skilled enough that they could selectively identify and embolize more distal bleeding vessels that would dramatically shut down pelvic bleeding.

But this introduced a conundrum. OR vs IR? Where to go after the trauma bay? I've long said that the only place an unstable trauma patient can go is to the OR. Not CT, and certainly not the radiology department.

Only the OR, because that's the only place that something can actually be done about the bleeding. **However, that's not entirely true now.**

Here's the traditional algorithm for a patient with hemorrhage from pelvic fractures:



They go to the operating room **OR** interventional radiology. If they start in the operating room and can be stabilized (think external fixation and/or preperitoneal packing), then they might be able to be packaged and taken to IR for embolization. And likewise, if they were initially stable enough to go to IR but crash there, then they must immediately be taken to OR.

But what if you could do both in one room?! That's the beauty of the hybrid room! It is entirely possible to do two, three, and maybe more cases on the same patient in the same room. Hence, the hybrid OR.

Is The Hybrid OR For Trauma Useful?

Gee, the hybrid OR sounds like a great idea for specific trauma patients. But we've seen this before; great idea but doesn't always translate into a positive result. **Is there any literature?**

Unfortunately, very little. A group from the University of Calgary in Alberta published a very detailed paper on the nuts and bolts of how they designed their hybrid room from scratch. This paper is very detailed, and the hospital personnel were very thoughtful as they approached the time-consuming and expensive task of designing and building their hybrid room. Of course, they chose a silly acronym as so many do. They called it their RAPTOR room (Resuscitation with Angiography, Percutaneous Treatments, and Operative Resuscitations). Sigh!

Next, they retrospectively analyzed their experience with persistently hypotensive patients arriving at their Level I trauma center over a 17-year period before their hybrid room opened.

Here are the factoids:

- Of 911 patients, 510 remained persistently hypotensive (SBP<90 torr)
- 53% (270 patients) were taken directly to OR, usually for laparotomy, thoracotomy, or vascular procedure
- 29% were admitted to an ICU, 13% to a ward bed, and 5% were taken to interventional radiology (IR)
- **35 patients (7%) required both OR and IR;** the majority had pelvic fractures (77%), the rest had liver lacerations
- Each case was reviewed, and overall **6% of patients would have clearly benefited from a hybrid room, and 30% would have potentially benefited**

Sounds good so far! But we need some more data. Unfortunately, there's not a lot of it yet. A Japanese group described their experience with treating patients in OR then IR, vs a "hybrid procedure." This did not involve the use of a true hybrid OR. They moved a C-arm fluoroscopy unit into an OR and part of the procedure was carried out by an interventional radiologist.

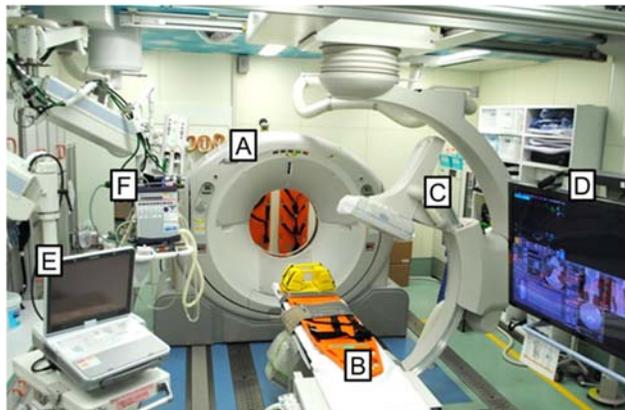
And the factoids:

- A total of 13 "hybrid treatment" patients were compared to 45 who underwent both operation and angiography, but not in the same location
- **Most of the hybrid patients had a laparotomy,** but there was a concomitant thoracotomy in one and a craniotomy in another
- **The actual survival in the hybrid patients was 85%, while TRISS predicted that only 62% would live**
- There was no difference in transfusion volumes between the two groups, but **total procedure time was significantly shorter in the hybrid group** (4 hours vs 6 hours)

Okay, sounds promising. A second Japanese paper was published last year with much larger numbers. Their hybrid OR was actually a hybrid ER! They installed a multi-slice interventional radiology/CT unit in their resuscitation room! Here are the key findings:

- A total of 696 patients were reviewed over an 8-year period – 336 hybrid and 360 conventional
- **Mortality was very significantly decreased in the hybrid group**
- **OR start was significantly shortened from 68 minutes to 47**

Here's an image of their setup:



Key: A – mobile CT scanner, B – CT / OR table, C – mobile C-arm, D – 56" monitor, E – ultrasound, F- ventilator

Bottom line: This is quite a unique room. Unfortunately, it is not ideal because it is small and cramped. It looks like it would be difficult to fit more than one surgical team in the room. However, the results look good.

We are finally starting to see objective data involving a reasonable number of patients. A minority of trauma programs have a hybrid OR available to them, and the number of patients who would benefit from it is low. But if a patient needs it, this setup can be life-saving. So who are those patients, exactly?

References:

The evolution of a purpose designed hybrid trauma operating room from the trauma service perspective: The RAPTOR (resuscitation with angiography percutaneous treatments and operative resuscitations). Injury 45:1413-1421, 2014.

The potential benefit of a hybrid operating environment among severely injured patients with persistent hemorrhage: How often could we get it right? J Trauma 80(3):457-460, 2016.

Hybrid treatment combining emergency surgery and intraoperative interventional radiology for severe trauma. *Injury* 47:59-63, 2016.

The Survival Benefit of a Novel Trauma Workflow that Includes Immediate Whole-body Computed Tomography, Surgery, and Interventional Radiology, All in One Trauma Resuscitation Room. Ann Surg 2018, Epub ahead of print.

Which Patients May Benefit From A Hybrid OR?

The key to answering this question is to look at the resources that a hybrid OR brings to bear, and then determine what types of patients can take full advantage of them. Sadly, we have no guidance from the trauma literature, so we need to let our imaginations run free.

The basic concept for hybrid room use is this:

“My patient needs interventional radiology plus at least one other surgical specialty procedure”

The additional procedures don't necessarily need to benefit from or utilize the IR capabilities. But they do need to be of an emergent nature. For example, a patient with a pelvic fracture can undergo angio-embolization and pelvic external fixation, while the gynecologic surgeons repair a vaginal laceration. Simultaneous, but not related to the embolization.

Here's my list of possibilities. It is by no means complete or exhaustive. It's just a start. All include the interventional radiologist for some part of it:

- Pelvic fractures with angioembolization plus:
 - Preperitoneal packing
 - Perineal / gynecologic repair
 - Laparotomy
- Liver angioembolization plus laparotomy
- Thoracic aortic injury plus laparotomy
- Angiographic assistance for management of vascular extremity injury
- Any of the previous procedures plus craniotomy*
- And don't forget to toss REBOA in with this!
- Plus some other stuff I'm sure you will think up

So You Want Your Own Hybrid Room?!

You're hooked! You are thinking back to a number of cases that you think might have done better with a hybrid room. And now let's assume you already have one in your OR suite. Now what do you do?

The key is to avoid jumping right in and sending your next eligible patient straight to that room. **You absolutely must take some time to develop policies and guidelines to make sure things go smoothly.**

Here are some important things to think about:

- Identify which specific patients are eligible so you don't squander this resource
- Who calls the OR to secure the room (surgeon, resident, other)?
- Who calls the interventional radiologist?
- What if another case (TEVAR, etc) is already on the table?
- What if another case is getting ready to use the OR? How are conflicts resolved?
- Develop an initial in-room report process so all the teams know the game plan
- Assign an extra circulator to the room. You'll need them!
- Make sure all retractor systems (abdomen, head) fit the table! Remember that little asterisk in the previous section? Some retraction systems may need adaptors to work with your table. Don't find this out at the last minute!
- What about lithotomy position? How will this work with your hybrid table? They don't have sections that break away.
- Ensure radiation protection for all, including thyroid shields.
- Bag the bottom x-ray detector, otherwise it will get very, very gross!
- Create an external fixator equipment cart that can be moved into the hybrid room.
- Create an embolization cart with appropriate wires, catheters, coils, etc. This stuff may not be stocked normally in the hybrid room

And I'm sure there are more details that I haven't thought of. If you have some helpful suggestions, policies, or protocols, please share them with me!



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