Return on Investment of Continuous Patient Monitoring: An Interview with Eyal Zimlichman, MD

Pat:

Hi, this is Pat Iyer. This is the podcast from the Physician-Patient Alliance for Health & Safety. The podcast that we are presenting today is called the Return on Investment of Continuous Patient Monitoring. Welcome to our podcast. With me today is Dr. Eyal Zimlichman, a physician who practices in both Israel and the United States.

Pat:

Could you please tell our listeners about your clinical background?

Eyal:

So, my clinical background is - I'm a specialist in internal medicine and I practice also as a hospitalist, as chief of a medical center in Israel. Most of my time has been spent doing administrative work and management as the Chief Quality Officer at the Sheba Medical Center. I also practice research on quality and patient safety, especially relating to technologies at Brigham and Women's Hospital in Boston where I've worked for four years, up until three years ago.

Pat:

Terrific. That's an interesting position and I'm not aware of that being a common position of working in research on quality and safety. Certainly sounds like it would derive a lot of important information for patient care.

Eyal:

Right, and the ability to sort of play with between these three worlds of doing clinical work, practicing as a healthcare executive as Chief Quality Officer, and also doing research in this field, I think is a very unique ability to go from the research side to the implementation side and understand them both.

Pat:

Excellent. I know that we've talked a lot in health care about evidence based medicine and it sounds like you are right there in the middle of it.

Eyal:

Well, we try. That's a part of what doing the research is all about. I've been trying to improve our outcomes and through improving patient safety and quality, of course.

Pat:

I know that you've been working on a project and obtained some results by using a continuous monitoring system on a general medical surgical unit. Could you give us some background about where the study was performed in terms of the locations, the type of hospital, or the types of units that were involved?

Eyal:

Of course. So this specific study was conducted in a downtown community hospital in Los Angeles. What we did was we had one study unit which was a medical surgical unit within that hospital with 33 beds, and we had continuous monitoring technologies installed, which we'll talk about in a minute.

Installed in each of those 33 beds, with the idea that we want to study what the affect would have of being able to have continuous monitoring on general floors, which is, of course, not something that we do normally.

Pat:

Yes, yes, I'm quite familiar with the technology because of working as a medical surgical nurse for years. Just the type of unit that you were discussing. Why do you think it's important to use continuous patient monitoring systems?

Eyal:

Well, first of all we know from research done in the past 20 or 30 years that usually, we could detect maybe six to eight hours in advance before the patient actually goes into cardiac arrest. So there are early signs that can be detected within that time window and would allow us to maybe prevent that fatal event or most fatal events.

Once we get to the cardiac arrest, on average, we have between 15 to 20% chance of the patient coming out alive. Obviously we want to improve those percentages. And if we want to do this, we have to identify that the patient is deteriorating ahead of time and respond so that we prevent the cardiac arrest.

Once we know and understand that there is that window of opportunity, we have to be able to identify it and then act. And we know mostly how to act. We know how to treat sepsis. We

know how to treat other conditions that could cause mortality within hospitals, but the problem is with the detection piece.

And as we are all aware, mostly in general floors, we have intermittent vital signs checks. These checks would go somewhere between every six hours or even eight hours or sometimes four hours, but certainly not continuous. And within that window of opportunity of six to eight hours, we are always in the danger of missing it completely.

So by the time of intervention between one vital sign check to the other, we actually would get to the patient bedside only when he goes into cardiac arrest, if that deterioration occurs. So being able to continuously monitor patients on general floors, much like we do on ICUs, could be something that would make a significant contribution to preventing these preventable deaths inside hospitals.

Pat:

Those are excellent points and certainly it points out the dangers of the periodic monitoring of vital signs versus continuous. And then also another piece that you didn't mention, is that if the vital signs are being monitored periodically sometimes the person who's taking those vital signs doesn't understand the implications of the patterns that are occurring and doesn't report them and then the action stops at that level. So, I can see why continuous monitoring would be so much safer.

Eyal:

Right, and this specific technology we were looking into, it wasn't just a continuous monitoring, but it also was being able to look on trend alerts. So the alerts were not only threshold alerts that when you cross a certain threshold on respiration rate or heart rate the alert sounds.

But, it also looks at the trend and if the trend is pointing toward deterioration in the clinical condition, in hemodynamic condition, the alert goes off, so it's a more sophisticated type of alert. More fitting for general floors than maybe the we're seeing in ICUs.

Pat:

I'm curious about the equipment that you used in the study. Could you describe what it was like, how big is it, what does it monitor, where does it go on the bed, how is the data displayed? Give our listeners a picture of what this looks like please.

Eyal:

Sure. So, specific in this study we were looking at the device manufactured by a company. And it has a couple of attributes that are very important, I think, when we talk about monitoring on general floors. First of all, we're talking about a sensor that is positioned under the mattress.

Now the sensor is a very sensitive piece of electric sensor. Basically saying, it measures pressure or movement on the bed in a very, very sensitive way. By doing that the algorithms that are fitted within this device allow it to identify from the movements, from the pressure differences, the heart rate and the respiration rate and of course other types of movements that

the patient might be doing.

And this is quite unique because, first of all, it allows us to monitor heart rhythm, respiration rate in a non-contact fashion. And if we think about this, when we talk about patients on general floors, this ability is a really fitting attribute because many of these patients want to move around.

They don't want to be confined to bed. And if they do want to get out of bed, usually they would need a nurse that needs to come and unhook them from ECG electrodes or oxygen saturation sensors. In this type of technology, the patient can just get out of bed if he can and, of course, that's a big positive, a big advantage of this system.

So that's one attribute. Next to the bed. There is a bedside monitor that shows respiration rate and heart rate and movement for that patient. Now, unlike other monitors that show you, for instance ECG monitors, that show you that you are false on a given second, this device gives you the average of the past couple of seconds.

Whether it's half a minute or two minutes for respiration. And in that session, the number you see on the screen sort of filters out much of the noise that we see if patient moves, and that it affect his heart rate or respiration rate or any other thing that could be, an artifact in the measurement.

So, we filter out many of these artifacts and the measurement we are seeing is much more accurate or much more actionable. And then, when the alert actually sounds, that alert can be either because a threshold was passed on average for points of time or because a trend alert was activated.

And trend alert looks at the last 24 hours for that patient and gives us a trend alert for that time period of 24 hours. Now the alert sounds could either be found on the bedside monitor or it could be found on a device carried by the nurses and it could be different types of devices.

We were using pagers for the nurses on this. So each nurse got a pager that would alert only for the patients that were assigned to that nurse. And also at the central nurse's station there was in this study a big monitor that showed all the patients in the ward with their vital signs, movement parameters, and other parameters as we were looking into.

As a side point, I would say that apart from measuring heart rate, respiration rate, and motion, there are two other attributes which I won't be talking as much but only mention here. One of them is an indicator that the patient is high risk for pressure ulcers. Of course, with the idea that this would actually prevent pressure ulcers and another one is an alert preventing falls.

We won't be talking about this, this was not part of the study but it is another attribute of this system.

Pat:

Okay terrific. I know that our series has been focusing on the harmful effects of sedation and respiratory depression. Could you explain the clinical impact of those early changes in heart rate, respiratory rate, and oxygenation?

Eyal:

Sure. So, one of the things that is critical to mention and I think it's worth putting two or three minutes on this is the issue of respiration rates. Respiration rates - we relate to it many times as the neglected vital sign. The reason we call them neglected vital sign is because we don't have a good method, a good technology to measure respiration rates currently on most places.

What we do is manual count and when we do manual counts, many times they seem accurate. We don't really wait 30 seconds or a minute to actually count respiration rates is one problem. Second problem is the patient can control his respiration rate. So if he knows we're counting, he could affect it either by breathing quicker or slower.

So, we have an issue with measuring respiration rate when we do this on a point estimates. Unlike blood pressure or heart rate or oxygenation where we use a device and we take off from the device the measurements, this is being done manually. There is no good technology currently to measure respiration rate outside of sleep labs unless of course we're talking about ventilated patients, and then we have that from the ventilators.

So, other than that we're currently measuring respiration rates mostly manually. By being able to measure respiration rates very accurately, as this device does, and doing this continuously It gives us a hugely important information piece to understand how the patient is doing and of course this is very much in the case when we talk about sedation.

We know from many, many studies that have been done in the last couple of decades that when we talk about patient deterioration, respiration rate plays a vital sign or a major sign in actually identifying those in front. When we have patients going into shock whether it's because of sepsis, whether it's hemorrhagic shock because the patient might be after surgery and bleeding because of a complication, or if the patient is going into pulmonary emboli or any of these complications we tend to see in hospitals, most of those if not all of them would be shown on a respiration monitor.

When we talk about sedation, being able to measure respiration rates with saturation gives us the complete story of how our patient is doing in terms of ventilation. And of course we're worried about having patients on sedation going into apnea and that would be captured by this type of device.

There are other ways to do it - you could use capnography, of course, which is a great tool for these purposes, but capnography has it's own limitations. It's not contact-less - it has to be, it's pretty uncomfortable and if we need to put this on every patient on the general ward, I think we could all appreciate this would be an issue.

So again coming up with a device that will allow us to do this on all beds in a general floor and being able to measure ventilation. And also oxygenation, if we have the patient on oximeter, would solve that issue.

Pat:

I think it would help our listeners if you could share with us a description of somebody whose life was altered by the use of the equipment that you have identified. Could you tell us about somebody that you cared for who was involved in this study who had a positive impact from this?

Eyal:

Sure, I can think about two examples. One is actually in the previous study we've done back in 2008 where we used this device, but it was in a non-interventional study. Basically, we had the devices recording but not alerting and the ideas was that we will look retrospectively on how our heart patients were doing and how they monitored on the device.

And we had one specific case in which it was a relatively young person in his 50s, healthy, no other co-morbidities, and that he came with a bad pneumonia to the emergency department. I was actually the physician in the ED at the time, admitting that patient to the medicine ward.

And then, after two days, I came to see him in the department and his condition was much worsened. The patient was on the device, was monitored by the device, but the alerts were closed at the time, because this was a non interventional study. When we saw the patient's condition was deteriorating, mostly respiratory condition, we sent him for an emergency CT scan which showed a vast necrotizing pneumonia. The patient was then intubated, transferred to the Emergency Department, sorry to the ICU, was in the ICU for about five days.

He was intubated and came back to the medicine ward for another two weeks in a very poor condition and then went on to rehab. When we looked back at the data coming from that patient, we could've known 24 hours ahead of when we actually noticed that the patient condition has worsened, that something has gone south. If we would have known that 24 hours ahead of time, if those alerts would have been open and we would have known about that condition, 24 hours ahead of time, I would argue that there's a good possibility that maybe his condition wouldn't have deteriorated as much.

Maybe he wouldn't need an intubation and wouldn't have gone to the ICU and the whole course of his acute illness would have been altered. And so this is a case where the device was only measuring and not alerting.

There's another case, and this was when the device was actually alerting and we used it when we had a patient who was an alcoholic patient with severe liver cirrhosis, came to the hospital and was hospitalized because of signs of coma and after about two days on the floors, his condition started deteriorating.

We got an alert from the device. We sent the patient to some tests and we found out that he started bleeding from viruses in his esophagus. He's hemoglobin came back at about five or six, and we intervened in time and maybe saved his life because of that earlier warning we got through this.

So the patient was losing a lot of blood, went into a hemorrhagic shock slowly and slowly, but was diagnosed fairly quickly in the process, I would say. And again, we don't know what would

have happened if this was not the case, if we didn't have the device, but I can certainly say that the early warning probably improved his outcome.

Pat:

Tell us about how continuous patient monitoring impacted the rapid response activations in the facility.

Eyal:

Well, we tend to say now that we've looked into the importance of continuous monitoring, not just on this study but on other studies and using other technologies, that we think currently and I think that's a common notion today among the experts that continuous monitoring is what we call the missing link to making rapid responses to the work.

And by that I mean, of course, the evidence we had in the last ten, 15 years showing some question marks on the effectiveness of rapid response systems. And you know I don't have to remind our listeners of a couple of studies. One such study done in Australia was published in the Archives of Internal Medicine and some other similar studies in meta analysis that have shown that hospitals have implemented rapid response system have not shown an improvements in outcomes, have not shown a decrease in mortality that we were aiming to see.

And there is always that question, why is that the case?

And, if we look closely into rapid response systems, we know that there's an efferent and an afferent limb. We're mainly saying that there is, first of all, understanding that there's a need to activate the team and then, once we understand that, there's the actions that the team take.

So, how do we get the team to the bedside and then what does the team do once they're there? The teams are, this is quite unanimous, are professional enough to know how to handle these cases. They're mostly ICU docs and nurses and they treat these cases on a day-to-day basis. And, when they get to the bedside, generally they know what to do and they can save the patient.

The big question and challenge is around getting that team, that teams of professionals to the bedside as soon as possible. And this is where we've been lacking before we started using continuous monitoring.

So again if we talk about the vital signs, the point estimates, we all know that there's a chance that we would be missing the signs of deterioration because we're getting to the patient bedside once every eight hours for vital signs, for instance. So, in that fashion, just having continuous monitoring and being able to have our alert come off earlier than we would've diagnosed that the patient is deteriorating is one huge factor.

The second I would like to mention is how the nurses react. So we know, and again this has been studied in the past, that one cause for making rapid response systems, let's say not be as efficient or as effective as we'd like them to be, is uncertainty coming from the nurses' side on when to activate the team.

Sometimes a nurse thinks “I'm not sure whether this is justifiable”. Sometimes the team comes over and says, “This is not a case you should've called for us. You need to think about this again the next time you think about calling us” and that deters the nurses from calling them again and that hesitation could have negative outcomes on the patients.

When we have that these kind of devices in place, the alerts that sounds and alerts the nurses give the nurse an extra layer of confidence that this is an event worth activating the team for. And especially the nurses know some of the data that we've been publishing on this device specifically and other similar devices saying basically that positive predictive value of these type of devices when they do alert us, positive predictive value is at around the 50% mark.

Basically saying, on every alert we get, there's a 50% chance that this patient would need an ICU. When the nurse gets that alert on top of her clinical judgement, it reinforces her decision making and I think that factor alone contributes to a better and efficient activation of the system.

Pat:

Lets talk about the cumulative effect of the equipment alarms because you've talked about the alerts and there's a lot of focus now in patient safety circles and in Joint Commission on an equipment manufacturers about the alarm fatigue that can occur. How does this system affect that issue?

Eyal:

Well, that’s a great question of course. Alarm fatigue is a huge factor and something we all need to be worried about and any new technology that comes out has to take this into affect. When we talk for example about telemetry, we know the alert fatigue on telemetry is huge.

There are cases and sentinel events we all hear about, we read about in papers where a patient was on telemetry because the alert went off so many times. Sometimes the alert thresholds are changed, the alert is turned off, or something like that, or the nurse doesn't react in time because they alert sounds so many times, mostly on false alerts.

When we talk about designing new monitoring technologies, we have to be cautious about that. And, of course, the new wave of technologies we'll be seeing of monitoring technologies is going to be looking more and more into what we call today smart alerts. Smart alerts are alerts that not only signal or alert when a certain threshold has been passed, but they have certain filters that they enact.

They have a certain analytic engine that would act on top of numerous vital signs that are monitored, all with the intention of improving the accuracy, reducing false alerts, and improving positive predictive value. Specifically with this monitor again and the research we've done, we've shown that positive predict value, as I've said before, was in the 50 to 60% range and negative predictive value was 90 to 95%.

Mainly saying if the device is silent, there's about a 95% chance everything is okay. If it does sound, there's a 50 to 60% chance that this patient would need an ICU transfer. So when you get to these types of rates, this is where we want all of our monitors to be at or maybe even improved rates than what we've seen with this as we go into the future.

The other thing is how many times have we had these alerts go off? On average, if you were talking about telemetry, a nurse on a shift might be able to get tens if not more of alerts per shift. In this specific study, we've looked into that with this specific technology again as an indication of how new technologies need to act.

And specifically in this trial, what we found was that for every nurse caring for eight patients per shift, every nurse has got two alerts on average per shift. One of those alerts were deemed necessary. The other was not. And again, it goes to the 50% positive predictive value we've measured before.

So when you get only two alerts per shift, you better act when you get that kind of alert. When you get a hundred alerts per shift, obviously you get alert fatigue and you might not react timely to every one of those alerts.

Pat:

And was that two alerts per eight patients or two alerts per patient?

Eyal:

Per eight patients per shift.

Pat:

Per eight, okay.

Eyal:

Right.

Pat:

Okay, those are manageable numbers.

Eyal:

Exactly, and this is again, this is a type of new technology that we want to see come out. This is what the future would look like when we talk about smart alerts and continuous monitoring and it has to look like this. Because if we think about continuously monitoring every patient on medical floors using the current technologies of telemetry or saturation monitors, we're bound to have hundreds and hundreds of alerts per shift. And that of course is not sustainable, so we have to think about new ways to monitor patients.

Pat:

Another focus in your study I'm sure is on the cost of the equipment and the return on the investment of the equipment. Could you give us a sense about how much money you think the equipment saved on this nursing unit that you've been describing to us?

Eyal:

Sure. So, first of all, we all know that financially we have to be looking on everything, every new equipment we introduce. We have to understand if we are seeing cost savings and what's the financial model and what's the return on investment. And we've utilized the methods that was devised by my team in Boston at Brigham Young Women's Hospital for calculating returns on investment on technologies.

And basically what we've seen, after we've looked at the numbers and cost savings from this technology is attributed to reducing length of stay In the hospital on the general floors, in the ICUs. We know every day saved in the ICU means a lot of dollars saved and reducing pressure ulcers, which was another factor of what we've been looking in a different published paper.

So, when we factored all of that potential savings and factored in the costs of the technology, we actually have gotten to a break-even point of six months. Which means after six months after you purchase this technology and implement it, the return on your investment of the technology and then after this period, of course you actually save money.

Now every financial model and return investment has to have some sensitivity analysis because there are ranges and estimates abound here. And when we do a sensitivity analysis and we look at the different estimates and then we say, well, maybe we're not reducing by x percent. Maybe it's x minus ten or x plus ten and we introduce all of that into our calculations.

Even though we look at the most conservative models, we still remain with about nine months of return on investment. I've done some studies on return on investment for other technology and specifically for health information technology applications in the past, and I could tell you having a return on investment of six to nine months is very, very, very good.

We're not seeing this come out of other publications for other types of technologies. EMRs, CPOE systems usually have a return of investment that spans somewhere between three, five, maybe seven years. That's the general rule we see with health information technology, so this is in a different ball game all together.

And the reason we're seeing this is easy. The reason is the dropping ICU bed utilization and dropping length-of-stay mostly in the hospital. And when we talk about prospective payments, when you're being paid by DRG, then that is translated into actual cost savings.

Pat:

We started talking today about this technology in one unit in Los Angeles with 33 beds. What has happened since that study completed?

Eyal:

Well, there are other studies going on right now. We have a bigger study going on just outside of Boston in one of the apartments healthcare hospitals in Newton. That's been going on for more than a year now, we're looking to get the numbers from that one, as I said it's bigger.

It's comparing two floors to two floors. And we're anxious to see the result on that one. And then there's another study that just ended in at the Netherlands. Quite similar to the design of this study that was done in Los Angeles, only a bit of a different health care setting because it's a different country of course.

And we're seeing somewhat similar results there also. Of course, we haven't published this yet, but I can give the listeners sort of a first feel, the result seems to be similar, although again, it's a somewhat different environment, somewhat different incentive systems, and still we're seeing the improvements in dropping ICU utilization and NICU state.

Pat:

These are very encouraging results, and I thank you for sharing your expertise with our listeners. Is there anything else that you would like to share with us before we conclude this podcast?

Eyal:

Well, I think as a final note, I would reiterate the main message which is the importance of continuous monitoring. I think it's my notion that maybe ten years from now, we'll be seeing continuous monitoring on every bed in the hospital. It's industry's responsibility and ours as researchers to find the right technology to the right setting.

So, just taking ICU monitors and just putting them on every bed in hospital, of course, is not the right solution. We have to find the suitable monitors for the general floors, maybe other monitors for the emergency department or for a gastroenterology suite. So every kind of location needs to have the technology that fits that location.

And then beyond the hospital, of course, as we go through hall monitoring, and that's also one of the fields that's been progressing rapidly in the last few years. We need to figure out better how to do continuous monitoring at home, how to identify those trends and alerts with those trends and react early to signs of deterioration. So, I think we're entering a very exciting field and exciting time that would show us a lot of improvement in preventing preventable deaths which of course is something we're all aiming for.

Pat:

Wow, that is terrific. This has been Dr Eyal Zimlichman and Pat for the Physician-Patient Alliance for Health & Safety. Thank you for joining us in this podcast.

Eyal:

Thank you very much.