Discussion of 2021-1755

IMPACT OF CRYOABLATION ON PECTUS EXCAVATUM REPAIR IN PEDIATRIC PATIENTS

**DR BARBARA A GAINES** (Pittsburgh, PA): I would like to thank the Association for the privilege of discussing this study on the use of cryoablation for the management of postoperative pain in patients undergoing the Nuss minimally invasive procedure for pectus excavatum.

Pectus excavatum is a condition that occurs in 1 in 400 to 1000 children. It can be associated with cardiac and pulmonary complications, and more commonly, with significant exercise intolerance and severe psychosocial anxiety. In addition, the deformity typically worsens during puberty, accentuating the psychosocial implications. While in the past, surgical repair was performed in young children, this practice has been abandoned secondary to the feared complication of acquired Jeune Syndrome with the associated failure of chest wall growth.

Surgical technique has also evolved from the Ravitch procedure, which involved resecting costal cartilages to the minimally invasive approach popularized by Dr Nuss. In this procedure, the chest wall is essentially forcibly remodeled, and supported by one or more surgically implanted bars. While the Nuss procedure is performed through small, cosmetically favorable incisions and results in an excellent clinical result, it is unlike most minimally‑invasive procedures, in that it is considerably more painful than an "open" repair. Over the years since Dr Nuss first described the technique, pediatric surgeons, in conjunction with anesthesiologists and pain‑management specialists, have tried to develop optimal regimens for postoperative recovery for these patients. PCAs, thoracic epidurals and On‑Q pumps, have all been tried, with initial great enthusiasm later tempered by efficacy and complication concerns. At the same time, we have become increasingly concerned regarding the long‑term implications of narcotic use in adolescents and have developed clinical guidelines and pathways utilizing "multi‑modal" therapy and narcotic reduction strategies.   
 In the current study, the authors report on a large single center cohort of patients undergoing pectus repair, and compare the outcomes of those treated with bilateral intraoperative cryoablation of the intercostal nerves to "standard of care." Postoperatively, patients received intravenous narcotics via PCA, and then transitioned to oral narcotics. The study results demonstrate significantly lower narcotic usage and length of stay in the cryoblation group versus the "standard of care" group and no increase in complications.

I am curious to know how the patients were selected for cryoablation, and wonder whether there might be some selection bias in the groups. Does the "standard of care" group really reflect a cohort that underwent surgery in the early phase of the study before our "multi‑modal" pain medication or pain management strategies were fully developed? Could some of the differences observed be the result of better pain management protocols in the later years of the study versus not having a uniform protocolized approach to pain management? In other words, is it that we are better at taking care of pain in general or is it the cryoablation that really made the difference?

It was interesting to me that the pain scores were the same for both groups. If that was the case, why were the "standard of care" patients staying in the hospital so much longer?

Regarding the cryoablation procedures specifically, do all your surgeons who perform pectus repairs use cryoablation? What is the learning curve regarding the use of this technology?

I am also interested in whether there were any late complications from the cryoablation. While patients were discharged home earlier, did they develop late neuralgias, troubling hyperparesthesias, areas of persistent numbness, injury to the sympathetic chain or other complications associated with the procedure?

Finally, while this paper is focused on cryoablation for pectus repairs, I was wondering whether you were using it for other thoracic surgical procedures and with the same success.

**DR RAVI S RADHAKRISHNAN** (Galveston, TX): Pectus excavatum patients have a significant amount of postoperative pain, which presents a significant challenge for the surgeon taking care of them. The authors have examined the efficacy of intercostal nerve cryoablation in controlling postoperative pain in pediatric patients undergoing pectus excavatum repair and have demonstrated that intraoperative cryoablation significantly reduced postoperative pain. I would like to congratulate them on their work and believe that this will significantly change the way we manage postoperative pain in this challenging patient population.

I see mentioned in your paper that only 3 patients received an epidural. Is that the standard in your center? What was the reason for not having an epidural for postop pain management, especially for the NCA or non‑cryoablation group? Do you feel that comparing cryoablation to an epidural catheter would change your results?

Regarding cryoablation therapy, my method section states that you applied the cryoprobe to ablate intercostal nerves 3‑6 bilaterally. In reviewing the manufacturer's recommendations, they recommend ablating nerves 3‑9 bilaterally to help with postoperative pain control. Was there a reason for this change? Since your results show significant improvement in postoperative pain and very little opioid use, do you feel that we only need to ablate nerves 3‑6 to achieve adequate pain control?

Some pediatric surgeons, albeit anecdotal, have reported poor postoperative pain control with cryoablation. In your data, were there any patients who did not get adequate pain control from cryoablation and were removed from the study? If not, were there any specific techniques that you used to ensure that the failure rate was low, and did you use any other blocks, like intercostal blocks to bridge pain control until the cryoablation became effective after 24 hours?

Pectus repair has always had specific criteria from the Haller index, ranging from cardiopulmonary impairment, pain, to psychological concern for it. In the past, surgery has only been offered for a select few patients with severe symptomatology largely because of the significant pain caused by the procedure. With pectus excavatum repair heading toward an overnight stay or a day surgery procedure alone, do you think we need to revisit our criteria for surgery to be able to offer this to patients with less severe pectus excavatum?

**DR JOHN HANKS** (Charlottesville, VA): Can you give us a little bit of information about the cost of the probe and any cost analysis? Is that balanced by any savings you have by shorter hospitalizations or decreased opioid or medications?

**DR SAMIR R PANDYA** (Dallas, TX): The first question pertained to how patients are selected. Our study spanned a long period from 2009 to 2020. We started using cryoablation in 2018, and since then, every patient got cryoablation. Hence, there was no patient that did not get cryoablation once we had started the use of the technology and thus the study.

Were multi‑modal regimens same in the earlier to late period of study and was the impact of cryoablation alone compared to the introduction of multi‑modal pharmacotherapy? Our multi‑model regimen predated our experience with cryoablation. Hence, the group of patients who did not receive cryoablation also has patients who did get a protocoled approach to postoperative analgesia. Hence, I suspect that these findings that we are presenting here today are truly due to the cryoablation and not due to the multi‑modal regimen. It was a very astute observation of the pain scores being the same in both groups, and I wondered about that myself after we wrote up the manuscript. It turns out that I made an error in my approach in that I looked at the pain scores as an average pain score for the entire hospitalization, as opposed to looking at the pain scores on a daily basis. That said, I do think that we can conclude that within 2 days we are able to get to the same pain score that what was originally taking us 4 to 5 days, if not more. We will be doing a subgroup analysis for that and will address it in the paper before final submission.

I believe the next question asked if all surgeons perform the cryoablation, and what is the learning curve. Yes, we have 5 surgeons that perform chest wall repair, and all of us do perform the cryoablation. In terms of the learning curve, we found that about 3 cases is all that we needed in terms of learning how to learn this technique. So, it was a rather gentle learning curve.

With regard to late complications, there have been reports in the literature of paresthesias in patients. There is a case series from UCSF in which they compared the late complications for patients who are under the age of 18 vs the over the age of 18. In this study they found that there was an increased risk of paresthesias in the upper abdomen in patients over the age of 18. They did not see any in those who are under the age of 18. In our group, we did not see any patients that had any paresthesias, and I suspect this relates to the answer that I will have for Dr Radhakrishnan in terms of the levels that we ablate in that we don't go too low, and that's why we don't have that issue.

Finally, you asked if we used this in other thoracic procedures, and the answer is yes. We have started using this for the thoracic procedures. We are not studying it, but anecdotally, we have found that it has been pretty helpful, especially when we do the thoracotomies for metastasectomies from osteosarcoma and such.

Dr Radhakrishnan's noted that we only had 3 patients that received an epidural in our study, and that is true. Specifically, this was in the earlier phase of the study, as in back in to 2009. What we found is that the epidurals just did not seem to work that well, and so we did not continue that. Some people in the audience have heard me say this before, I have a love/hate relationship with epidurals, in that I love the idea of what they tend to want to provide, but I hate that they cannot do so. So, yes, we do not use epidurals for chest wall patients.

In terms of the way that we do the ablation, the manufacturer's guidelines state that the two rib spaces above the highest incision and two rib spaces below the lowest incision should be ablated, but they caution you not to ablate anything above the third rib space and below the ninth rib space. In our approach we have solitary incision for the pectus repair, we just go a couple of rib spaces above and a couple below.

With regard to whether we have any tricks that we use until we have full efficacy of cryoablation, the answer is yes. We use an intercostal block that we administer while we are doing the ablation. For this, we use liposomal bupivacaine and dilute it down to administer 2 CCs in every rib space, and we have found that that helps us additionally to achieve a very well tolerated pain score.

Finally, as we head towards the same day discharge, whether we should be revising the inclusion criteria for those who undergo repair of pectus excavatum, this is a great point. As you may know, the Haller index is what is typically considered to be the gold standard as to who gets the repair and who does not. Interestingly, that was just a line drawn in the sand. There is no correlation between the actual three and a quarter threshold and severity of disease, it was just a ratio and threshold developed from an evaluation of a single surgeon's experience.

I am therefore very much in favor of revising the criteria. I am worried that it will be difficult to convince our third‑party payers that we should do so, but I look forward to having more offline discussions with you to explore if there is a way that we can move that needle.

Dr Hanks asked about the cost of the cryoablation. This is a disposable instrument that is attached to a generator. The cost that has been shared with me is somewhere in the range of $2,500 for each probe, for single use. That said, if this is helping us cut down our hospitalization by two days and decreasing the opioid use, I think it is a reasonable price to pay.