treated at hospitals with an annual volume of less than 10 (9% of all resections) or an annual volume of less than 30 (45% of resections).

Given the relationship of volume to outcomes, and in the interest of continued and continuous quality improvement, hospitals should be aware of their annual volume for major pulmonary resection and their institutional mortality associated with those resections over time (at both 30 days and 90 days) compared with national data. Although our methodology and analysis did not allow us to identify an absolute break point or optimal minimum annual volume, our data suggest the more the better and that mortality continues to decline with increasing volume. Benchmarking outcomes against those institutions performing more than 30 resections per year would attempt to address much of the variation currently seen, and has practical value. Those hospitals with low volume and/or high mortality can then develop strategies to address the differences in outcomes for their patients compared with those treated at higher volume institutions with lower mortality. Specific strategies to address low volume and/or high mortality of major pulmonary resection are beyond the scope of this report, but should be explored through future efforts and investigation. To aid this process of continuous quality improvement, the CoC now reports annual hospital volume for major pulmonary resection, and 30-day mortality for those resections, to all CoC-approved programs using NCDB data submitted by the hospitals on an annual basis, as part of the Cancer Quality Improvement Program, and starting in 2014 also plans to report 90-day mortality.

References

Discussion
Dr Cameron D. Wright (Boston, Mass). Thank you, Dr Pezzi, for a wonderful, very clear presentation. Using the National Cancer Database to form a robust data set of 120,000 patients who had a lung cancer resection, the authors have demonstrated a modest, and I underline that word modest, volume/performance relationship with an absolute mortality difference of 2% between volumes less than 10 and greater than 90. The usual risk factors for mortality were identified such as age. The authors picked a somewhat arbitrary annual hospital volume of 30 without a receiver operating characteristic curve analysis to define low volume hospitals that they suggest should be carefully monitored in terms of their results. Their volume/performance relationship reporting is not new, and although this has been somewhat debated in the literature, most reports do indeed suggest there is a modest relationship, as this report does.

Of more interest to me is the substantial increase in mortality at 90 days, essentially doubling the 30-day mortality. This report corroborates 2 very recent reports that also suggested doubling of lung cancer mortality at 90 days, and in fact the mortality for pneumonectomy at 90 days was a very sobering 14.6%. It begs the question, are we misleading our patients when we counsel them about their perioperative risk? We need to learn more about what happens to our patients in this vulnerable period of time after they are discharged to see if we can mitigate that risk. Obviously this report cannot do that, but it certainly leads to an interesting hypothesis and more work to be done. I have 2 questions.

First, why is there more volume/performance effect in the first 30 days versus the conditional 90 days? The odds ratio drops from 2 to a just slightly significant 1.3.

Dr Pezzi. Thank you, Dr Wright, for those comments and for your first question, which is an excellent question. As far as the reasons why we see a greater effect of volume on mortality during the first 30 days than between 30 and 90 days, we honestly do not know, but I wonder if this might suggest that some surgeon- or institution-related factors are driving the 30-day mortality,
whereas perhaps some patient-related or patient disease-related factors, such as their tumors or comorbidities, are more responsible for mortality between 30 and 90 days? We do still see an effect on mortality between 30 and 90 days, but it is, as you pointed out, significantly less. But this is just a hypothesis. I certainly agree with you that we need to further study why these patients are dying between 30 and 90 days, and hopefully that will shed some light on what we can do to affect that mortality.

**Dr Wright.** And trending along that same line, where there is a volume/performance relationship for pneumonectomy for the 30-day mortality, there is none for the conditional 90-day mortality. Given the very large morbidity and mortality of pneumonectomy, in which another 6% die in that 60-day window, is this just a matter of small numbers? Why was that not significant? What is your hypothesis there?

**Dr Pezzi.** Again, the overall magnitude we saw across the board seemed to decline between 30 and 90 days compared with the first 30 days, and perhaps we are dealing with small numbers, although we did have 8000 pneumonectomies in this study, but perhaps it is just small numbers. Again, I wonder if it could be patient-related factors. I think as surgeons, we want to take responsibility for all mortality of our patients, not just within 30 days, but even if a patient dies 2 months later or 3 months later, I think we would feel that somehow our operation might have contributed or had something to do with that.

However, I think the longer we get out from the date of surgery, it is possible that other factors beyond our control that are not completely surgeon- or institution-related may be at play here, and perhaps that is why we see a diminishing effect of volume the further we get out from the date of surgery. This is just my best guess to try to address your question.

Thank you very much for your comments and questions.

**Dr Thomas K. Waddell (Toronto, Ontario).** I enjoyed your presentation. I want to follow up on Dr Wright’s question about why the conditional mortality is not different in different size of hospitals. Two questions to think about.

Are you able to describe any aspect of hospitals that have better versus worse outcomes in that conditional mortality and are you able to see postdischarge mortality as opposed to conditional mortality based simply on the time points?

And the second question to think about, you presented beautifully the evolution of 30-day mortality over time. Do you have any data about the evolution of conditional mortality over time? Is this also getting better or has it always been the same magnitude of problem?

**Dr Pezzi.** To address your last question first, I think it is an excellent question, and that is, we have traditionally defined surgical mortality as 30 days or during the initial admission, and so we do not have too much data on 90-day mortality over the decades. And so I guess the question that comes to mind is: has this mortality been there all along and we just did not notice it, or is there something different now that we are essentially pushing some of the mortality that used to occur in the first 30 days beyond 30 days? In talking to our surgical intensivists, they can keep sick patients alive longer, perhaps beyond 30 days, but maybe not beyond 90 days. And so are we just pushing on some of that mortality?

You talked about discharges. These are actually 30 and 90 days and have nothing to do with hospitalization. We really did not look at time of discharge or various hospitalizations. We are just looking at crude survival at 30 and 90 days.

I think this is important, because at my own institution, if a patient is doing poorly and they are not going to make it, and it looks bad, and they have been on a ventilator for 4 weeks, a lot of times they get sent to hospice and they are considered discharged at that point and they are readmitted to hospice. And so they would not be picked up as either a 30-day mortality or an initial hospitalization mortality. They are considered discharged. So I think that is an excellent point you bring up.

I hope I answered your question.

**Dr Tomasz Grodzki (Szczecin, Poland).** I have 1 short question. Why did you decide that 90 cases per year is high volume? European standards consider more than 200 as high volume. It means that it is 2 cases per week. If you have 3 surgeons, every single surgeon is doing less than 1 case per week. It is not a high volume.

**Dr Pezzi.** Thank you. That is an excellent question. It was, as Dr Wright pointed out and I would acknowledge, a weakness, that it was somewhat arbitrary how we divided our volume groups. I would point out that only 21 hospitals were in that high volume group out of 1200. So to set the bar even higher would have led to an even smaller number of hospitals.

**Dr Mark J. Krasna (Neptune, NJ).** Congratulations, Chris, to you and the authors from the Commission on Cancer. I believe 1 of the points also to take away from here, if I am not mistaken, is that the Commission on Cancer data are currently reported back to the hospitals, and it is not specified whether the surgeons performing the operations were thoracic surgeons versus nonthoracic surgeons. I do think it would be very interesting going forward in a prospective fashion if you could get granular data to identify not only the high volume from the low volume hospitals but also identify hospitals where most of the surgery was done by thoracic surgeons versus general surgeons.

I know in the past we have heard many papers about this, but I do think using the NCDB data, we could maybe put in that granularity and ask for that information going forward. I think it is a very good start.

**Dr Pezzi.** Thank you very much. Yes, the NCDB currently is a hospital-based registry, but they will be using National Provider Identifier (NPI) numbers to report surgeon-specific data going forward. It was not available in this data set, but in the future that will be available using NPI numbers.

**Dr Scott Swanson (Boston, Mass).** Nice paper. One quick question. You may have said it and I missed it. Why is 90 days the max? Do we know what happens at 4 months, 6 months, 1 year? Does it flatten out and do you know that?

**Dr Pezzi.** That is an excellent question. We did not look at that but I think we should.