Dr. Langer, Dr. Hancock, Members and Guests, Ladies and Gentlemen:

Good morning, bonjour. I am deeply honored to join you today as the MacLeod lecturer at this 2013 meeting of the Canadian Association of Pediatric Surgeons (CAPS). This is not my first opportunity to attend a CAPS meeting, but I have been an infrequent visitor and I thank you for having me return. In preparation, I did review the roster of my predecessors; a truly distinguished group I am pleased to join. This lectureship was established at about the time I finished medical school, so the early MacLeod Lecturers include some of my heroes and in more recent years, my mentors and colleagues, all with contributions that helped guide my personal career and shape contemporary pediatric surgery.

I know that Dr. Langer invited me to discuss an initiative we have begun in the United States that is designed to improve children’s surgical care by prospectively matching hospital and professional resources to the needs of individual children undergoing surgery. I will offer a vision and also describe a (provisional) specific plan that we have developed. We will review selected, and I think supportive, data. The data are U.S.-centric, but I have included information from elsewhere, including Canada when possible. I do think the issues we will discuss are worldwide in relevance and the principles in the proposal are broadly applicable. To those of you who attended the May 2013 APSA Annual Meeting, the proposal will be familiar as it was the subject of my comments at the APSA Meeting, however I do have meaningful new progress and some new data to report, some that is not yet widely known to our APSA members.

As I prepared to travel here for my first visit to Prince Edward Island, I spent some time trying to educate myself, on Google of course. I came upon a list of the top 10 things unique to Canada… naturally, hockey topped that list, but I observed that only a bit further down was the Canadian universal health care system. It intrigues me that despite the very different administrative system for healthcare here in Canada, many of the issues that we are going to discuss this morning have been points of vigorous conversation throughout this CAPS meeting. I have chosen to use this “top ten” format to summarize key aspects of this effort that I call the “Optimal Resources Initiative for Children’s Surgical Care”. I will move reasonably rapidly through these 10 major points. In the interest of time, I have been selective about the data. Some of it is published and therefore referenced. Some is new and not yet published – I will make that clear as well. I invite your critique, comments and thoughts.

1. Much of children’s surgery is done in a nonspecialized environment today

A national assessment of the hospital types where children’s inpatient surgical care is provided today in the United States was recently presented by Ziegler and associates [1]. The data are derived from the 2009 (most recent) KID database, a sample representing inpatient hospital discharges for the large majority of inpatient operations on infants and children done across the U.S. It is an administrative dataset, noteworthy for its size. Of 189,977 inpatient children’s surgical procedures done in the U.S., 87,110 (45.9%) were done in general hospitals. Although the types of institutions are characterized as (adult) “general hospitals”, “children’s units in general hospitals” and “children’s hospitals”, we do not have detailed information regarding individual...
Pyloromyotomy

  n=1777 ⇒ 32.1% General Surgeons

  n=780 ⇒ 52% General Surgeons

  n=9668 ⇒ 29% General Hospitals

  n=3500 ⇒ (1987) 43% General Hospitals
  ⇒ (2009) 1% General Hospitals

Fig. 1. Literature summary of environment of care for pyloric stenosis.

Pyloromyotomy is a procedure that most of us in this audience consider relatively straightforward. Who does these procedures and where are they done? (Fig. 1) The more important question, does it matter? I will address this in a moment. I will begin with Dr. Langer, as I suspect that these data are known to most of you. In the province of Ontario, between 1993 and 2000, about one third of pyloromyotomies were done by general surgeons [2]. Likewise, Dr. Pranikoff and colleagues in North Carolina, a medium sized state with a combination of both urban and rural areas, presented a cohort of 780 patients in 2002 with just over half of the infants having their procedures done by general surgeons [3]. To come back to the most recent U.S. national data from Dr. Ziegler and colleagues that I just mentioned, 29% of some 9668 patients, received their care for pyloric stenosis in general hospitals [1]. As I noted, this doesn’t tell us what the actual resources and training were for surgeons and anesthesiologists, but it does offer a contemporary snapshot, at least for the location of care in the U.S. at present. Lastly, Dr. McAteer, whose name will appear in several places in this talk with important data, has developed relevant data, currently in press with the Journal of Pediatric Surgery from the state of Washington [4]. He identified a cohort of 3500 patients beginning in the late 1980’s and demonstrated that there has been substantial shift in the care for pyloric stenosis. In 1987, 43% of children received care for pyloric stenosis in a general hospital, whereas only 1% do so at present in the State of Washington. It is noteworthy that the definition of a specialty children’s hospital in this analysis was simply the presence of a pediatric surgeon. This point is illustrated graphically in Fig. 2.

Likewise, in Fig. 3, using similar statewide population data for the years subsequent to 1987, we see a somewhat similar shift to a more specialized care environment for children with appendicitis in the State of Washington [4]. The upper (blue) line in Fig. 3 represents children under the age of 5 years where this trend is most apparent. The graph shows the percentage of appendectomy patients receiving care in a children’s specialty hospital over time.

This trend is not limited to the U.S. Fig. 4 shows data from the United Kingdom (UK) with regard to site where herniorrhaphy was performed [5]. The upper line at the left represents district general hospitals (nonspecialized centers) while the lower line rising to the right represents specialist centers over the decade from 1994–2005. Despite the evident shift to a more specialized care environment over time, note that the percentage of children receiving this care in a less specialized environment today approximates the US data I showed you earlier.

Fig. 2. Pediatric specialty environment as the site of care for pyloric stenosis in the State of Washington.

Fig. 3. Pediatric specialty environment as the site of care for appendicitis in the State of Washington.
I would like to shift now from these relatively simple procedures (pyloromyotomy, appendectomy, herniorrhaphy), to somewhat more complex neonatal procedures. The data in Fig. 5 are taken again from the work of Dr. Ziegler and colleagues [1]. You see in this table several complex operations in potentially fragile patients including Ladd's procedure for malrotation, esophageal atresia repair, pull through for Hirschsprung's and diaphragmatic hernia repair. I have highlighted two which I think all of us would agree are relatively complex procedures that benefit from the expertise and experience of a children's surgeon as well as a specialized neonatal environment of care - esophageal atresia and congenital diaphragmatic hernia. You see that more than 15% of these procedures were performed in a general hospital setting in the United States in this most recent sample. To go a step further, I have not shown the data here, but we do know from a recent report from Dr. Brad Warner that there is an institutional volume outcome relationship with regard to survival with congenital diaphragmatic hernia. He and colleagues demonstrated that survival is more likely if care is provided in an institution with more than 10 such cases annually [6]. I know of no non-specialty hospitals that reach this volume.

Lastly, Fig. 6 illustrates presently unpublished data provided to me by Dr. Li Ern Chen of the University of Texas Southwestern in Dallas [7]. The source of these data is again the KID 2009 dataset. Dr. Chen demonstrated that approximately 20% of all surgical neonates in the United States are definitively treated in freestanding children's hospitals at present, more than one-third are cared for in children's units within a general hospital, and approximately 45% receive their definitive surgical care in a general hospital setting. The data are very consistent for this high-risk cohort of neonates and the broader range of children's surgery from Dr. Ziegler that I showed you earlier.

To conclude this first of my 10 points, today, in 2013, substantial volumes of children's surgery, including relatively simple procedures, but also more complex procedures in higher risk patients such as neonates, are done in a non-specialized care environment. This is true in the United States, and also to some extent in Canada. Based upon my conversations and travels, I think this pattern is indeed quite common around the world.

2. A specialized environment is associated with better outcomes for some procedures. this is most readily demonstrable for complex procedures in high risk patients

In March 2013, the Children’s Hospital Association and the Organization of Children's Hospitals Surgeons-in-Chief commissioned the Cochrane group to do a rapid response review to look at the question of whether there is a demonstrable link between surgical outcomes and the environment of care. The findings were most compelling for congenital heart surgery. The literature examined included 28 relevant analyses with 248,164 patients. The team found that specialization for congenital heart surgery (largely based upon programmatic case volume) had a positive correlation with better outcome in 19 of the 28 analyses (68%) as measured by in-hospital or 30-day mortality. None of the 28 analyses showed a negative effect of higher volume. Eight (29%) showed no demonstrable correlation at a p < 0.05 level, while 1 was unclear. The conclusion of the Cochrane team was that specialized centers, largely defined by higher volume were “generally effective for reduction in mortality for congenital heart surgery” [8].

A provocative study from Dr. Chang in California makes a similar point [9] (Fig. 7). California maintains a relatively robust
statewide database that allows analysis of outcomes, in this case short-term mortality, and also demographic and geographic information. California has had at the time approximately 20 programs that performed congenital heart surgery. There is demonstrable variation in performance that does, by and large, correspond with clinical volume. Dr. Chang theoretically “closed” lower volume, low performing centers in California and transferred patients to the next nearest center. As one moves from left to right on this graph in Fig. 7, the number of centers closed and the number of patients transferred goes up. If one takes this exercise to the point where only a handful of high volume centers with the lowest mortality remain, approximately 80 deaths can be avoided annually in the State of California. To be clear, this represents congenital heart disease over one year, and in one state, only; the number of lives saved is theoretical. One of the more interesting observations in this work was that the average additional travel burden imposed on families was 12.7 miles to achieve these improved outcomes. Some of you will point out that 12.7 miles at rush hour in Southern California is a prohibitive travel burden. I won’t argue that point today, but I simply draw your attention to the correlation between high volume, presumably more specialized centers, and the differential outcomes achievable.

I’d like to come back now to data generated over the last few months by Dr. Chen who I mentioned earlier (Fig. 8). She is a member of a Task Force that we’ve put together to examine this problem and which I will describe in more detail in a few moments. Using the KID 2009 dataset, Dr. Chen developed a novel propensity scoring system to prospectively assign mortality probability for a high-risk cohort of surgical neonates. These are neonates undergoing high-risk intracavitary operations such as tracheoesophageal fistula repair, procedures related to necrotizing enterocolitis, and others that we in this room do every day. The projected mortality for this cohort was more than 5%. I point out that this is approximately twice the overall American College of Surgeons-NSQIP-Pediatrics neonatal surgical mortality, so it is a particularly high-risk cohort. As one looks at this graph, you see the irregular blue line, which is the actual observed mortality, and the straight green line that is the trend line. The observed-to-expected ratio is on the vertical axis so 1 is, of course, where observed and expected mortality match. Above the line (on the left) is not where you would seek care for your child or your family; below the line (on the right) is a favorable environment. On the horizontal axis, we have again used the designations “general hospital”, “children’s units in general hospitals” and “children’s hospitals”. Within each of these in this analysis we move from low-
volume on the left to higher volume on the right. The assumption again is that low volume general hospitals will have fewer children’s specific resources than high volume children’s general hospitals. You see that there is substantial excess mortality on the left in the general hospitals and meaningfully better survival in the children’s hospital environment. I call your attention to the point I made earlier about where neonates receive their surgical care today. More than one third of US children are operated on in the environment described on the left and delineated by the (red) oval. These data are soon to be published [7].

I would like to turn now to trauma. All of you in this audience understand the complex and often urgent needs of seriously injured children. Table 1 is taken from some work by one of my colleagues in Wisconsin, Dr. John Densmore, looking at young children with moderately severe injury [10]. In particular, these are children between 0–10 years of age with moderate and severe injury as delineated with an injury severity score (ISS) greater than 15. Note the highlighted mortality probability in a children’s hospital which is significantly lower than for either a children’s unit or a general hospital environment. Both the length of stay and the financial aspects were more favorable in this children’s hospital environment as well. One can critique the administrative character of these data, but the sample size here is many thousands of patients representing the majority of the US. The sample size makes it unlikely that these results do not reflect the environment of care. Table 2 illustrates where this cohort children received their care. Only 28% of these children received their care in the environment associated with the lowest mortality probability.

Some have suggested trauma related mortality is not sufficiently common to be discriminating. To look beyond this, here are data for splenic injury developed by Dr. Mooney and colleagues, again from the KID dataset [11] (Fig. 9). The raw rate of splenic removal after splenic injury developed by Dr. Mooney and colleagues, again from the KID dataset [11] (Fig. 9). The raw rate of splenic removal after splenic injury is shown by hospital type and the child’s age. From right to left, as one moves from the children’s hospital environment to a children’s unit to a general hospital, there is as much as a 5-fold differential increase in the rate of splenectomy between the specialized and the general hospital environments. This is particularly noteworthy as one moves from younger to older patients. Likewise, liver injury, as recorded in the Pennsylvania State Trauma Database, is associated with demonstrable variation in outcome that correlates to the environment of care. Here, outcomes after liver injury are shown relative to the type of trauma center where care was provided, that is an adult versus pediatric designation [12] (Fig. 10). To be clear, the severity of liver injury was not different among these institutions. One can see that both the overall mortality rate and the likelihood of operative management for liver injury were significantly lower, that is more favorable, in the pediatric trauma center environment in the State of Pennsylvania.

I believe these data in aggregate show demonstrably better outcomes for congenital heart surgery, for neonatal surgery and for trauma care when these are provided in a specialized children’s environment. Each cohort involves complex procedures and high-risk patients.

3. Specialized pediatric anesthesia is critical for safe contemporary children’s surgery

It has been known for years, actually decades, that there is higher risk for infants and children undergoing general anesthesia than for adults (Table 3). These are early and often quoted data making this point [13]. This table demonstrates a statistically significant, actually 3-fold higher, incidence of anesthesia related cardiac arrest in young patients. Dr. Keenan defined “young” as less than 12 years of age when this was published in 1985. To be clear, even today in 2013, the risk of cardiac arrest in neonates undergoing general anesthesia is about 10-fold higher than for adults, and for infants less than one year of age the risk is 5-fold higher than for adults [14]. It is important to point out that should anesthesia related cardiac arrest occur, the risk of death is approximately 25–30%. This is not a trivial issue.

To come back to Dr. Keenan’s work, a few years after the report I showed a moment ago, he presented data which clearly demonstrated the value of specialized pediatric anesthesiologists [15] (Table 4). His work was at the Medical College of Virginia and at the time they had both specialized and non-specialized anesthesia providers for

---

**Table 1**

<table>
<thead>
<tr>
<th></th>
<th>Mortality</th>
<th>Length of stay ≥ 8d</th>
<th>Charges &gt;$15,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children’s Hospital</td>
<td>4.9%</td>
<td>16.8%</td>
<td>33.3%</td>
</tr>
<tr>
<td>Children’s Unit</td>
<td>9.1%</td>
<td>25.3%</td>
<td>42.2%</td>
</tr>
<tr>
<td>Adult Hospital</td>
<td>7.4%</td>
<td>17.7%</td>
<td>34.7%</td>
</tr>
<tr>
<td><em>P &lt; 0.0001, χ²</em></td>
<td><em>P &lt; 0.0001, χ²</em></td>
<td><em>P &lt; 0.0001, χ²</em></td>
<td></td>
</tr>
</tbody>
</table>

---

**Table 2**

Types of institutions where injured children/adolescents received care in the United States in 2000, stratified by injury severity. KID 2000 Database.

<table>
<thead>
<tr>
<th>Age 0–10 years</th>
<th>Age 11–20 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISS &lt; 15</td>
<td>ISS &gt; 15</td>
</tr>
<tr>
<td>Children’s hospital</td>
<td>20%</td>
</tr>
<tr>
<td>Children’s unit in an adult hospital</td>
<td>23%</td>
</tr>
<tr>
<td>Adult hospital</td>
<td>56%</td>
</tr>
</tbody>
</table>

---

**Fig. 8.** Comparison of observed to expected mortality in surgical neonates across hospital types (by hospital volume) [7].

**Fig. 9.** Variation in the incidence of splenectomy by hospital type and patient age [11].
children’s care, but case assignment was not dependent on this training. He demonstrated a statistically significant difference between the performance of the two groups, with all of the cardiac arrests occurring with non-specialized providers and none occurring in patients receiving care from specialty pediatric anesthesia providers.

To move to an issue that is more common but less life-threatening, Mamie and colleagues [16] from Geneva more recently demonstrated differential performance among anesthesia providers with regard to peri-operative respiratory adverse events in children undergoing elective surgery (Fig. 11). In this figure, the shaded bars represent children with respiratory complications when cared for by a pediatric anesthesiologist, versus the white bars that represent similar events for non-specialized providers. In particular, pediatric patients undergoing otolaryngological procedures were more likely to have an anesthesia related adverse respiratory event (OR 2.74) and other procedures were likewise associated with more complications when procedures were done without children’s specialty anesthesia.

In the U.K. there has been guidance from the Royal College of Anesthetists since the late 1980’s when poorer anesthesia outcomes for children first became a focus of public scrutiny. There have been periodic publications from the Royal College offering recommendations in this regard. The most recent are shown in Table 5 [17]. While too detailed to review in its entirety, I simply call your attention to the first point here: “Anesthesia services for children require specially trained clinical staff together with equipment, facilities and environment”. In a related effort, Lunn et al. offered recommendations with regard to specific levels of experience for children’s anesthetists that were thought necessary to maintain their clinical skills (Table 6) [18]. You see here with stratification for patient age, a recommendation for 300 cases overall in infants and children annually. To be clear, this has not been formally adopted.

We have some relevant French data on the question of optimal pediatric anesthesia case volume thresholds to maintain competency. These data are based on a retrospective survey published in 1997 (Table 7) [19]. The authors demonstrated significant inverse correlation between annual case volume and the risk of anesthesia complications in pediatric patients with higher rates of complications associated with low volume anesthesiologists. The thresholds in this study are shown on the left. Anesthesiologists with fewer than 100 annual pediatric anesthetics have a 5-fold higher incidence of complications relative to those who do more than 200 such cases annually. These authors conclude, “we recommend that a minimum caseload of 200 pediatric anesthetics per year is necessary to reduce the incidence of complications and improve the level of safety in pediatric practice”. We will revisit this issue later.

4. A comprehensive (Level 3 or 4) NICU is essential for optimal surgical care of neonates

Neonates are among the highest risk patients we care for in pediatric surgery. It has been known for decades that clinical outcomes for newborn infants are dependent upon the neonatal intensive care unit environment in which care is provided. In the interest of time, I will show just one recent example from a robust body of literature (Fig. 12). This meta analysis was published in 2010 and demonstrates that for very low birth weight infants with both medical and surgical diagnoses [20], there is clear survival benefit when care is provided in a Level 3 NICU versus lower (resource) level NICUs. This is true for other neonatal cohorts and has been known since the 1970’s. The strength of this analysis is clear. I should point out that these data predate the most recent recommendations from the American Academy of Pediatrics on this point that were published in September 2012. This document created a level 4 NICU designation, recommending that surgical care be confined to either Level 3 or Level 4 nurseries [21]. In this newest document, Level 3 NICUs have pediatric anesthesia, pediatric surgeons and pediatric ophthalmologists; Level 4 NICUs have comprehensive, multidisciplinary environments with ready access to both medical and surgical specialists.

The American Academy of Pediatrics (AAP) is one of the most effective health policy voices in the United States. The AAP publishes periodic policy statements that aim to improve the health of infants and children. This group has done so with regard to neonatal intensive care units since the 1970s. These recommendations have included multidisciplinary input and the NICU recommendations have typically become more robust every few years. Importantly, the AAP has never had a verification or enforcement aspect to these recommendations, hence institutions can be self-designated. Because of institutional reimbursement policies in the U.S., there is powerful incentive to retain infants in an institution’s NICU and there has actually been some “de-regionalization” in recent years because of reluctance to transfer certain patients to higher levels of care [22].

### Table 3

<table>
<thead>
<tr>
<th>Incidence of anesthetic cardiac arrest.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of anesthetics</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Adult vs pediatric</td>
</tr>
<tr>
<td>&lt; 12 yr</td>
</tr>
<tr>
<td>&gt; 12 yr</td>
</tr>
<tr>
<td>Emergency vs elective</td>
</tr>
<tr>
<td>Emergency</td>
</tr>
<tr>
<td>Elective</td>
</tr>
<tr>
<td>Time</td>
</tr>
<tr>
<td>Daytime, Mon-Fri</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

* Determined by Fisher’s exact probability test.

### Table 4

<table>
<thead>
<tr>
<th>Distribution of cases with and without anesthetic cardiac arrest.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
</tr>
<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td>Nonpediatric anesthesiologist</td>
</tr>
<tr>
<td>Pediatric anesthesiologist</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

\( p = 0.048 \) (Fisher’s exact test).
recommendations and standards were actually implemented. In 2008, the American Pediatric Surgical Association (APSA) published a position statement which identified the necessity for a team of continuously available medical and surgical specialists to provide the optimal environment for infant surgery [23]. It recognized the need for well qualified, specialty trained and continuously available professionals including neonatal and pediatric anesthesiologists, radiologists and others. These principles were not quantified and again, no mechanism was created to verify that these recommendations and standards were actually implemented.

The needs of surgical neonatal patients are well known to the surgical community. In 2008, the American Pediatric Surgical Association (APSA) published a position statement which identified the necessity for a team of continuously available medical and surgical specialists to provide the optimal environment for infant surgery [23].

Fig. 11. Incidence and risk factors of perioperative respiratory adverse events in children undergoing elective surgery.

The data in (Fig. 14) [25] are taken from a landmark study on the subject of pediatric intensive care published in The Lancet about 15 years ago. To be clear, the system for clinical triage of critically ill pediatric patients in the United States today is not unlike that which existed for Trent in the UK, the underperforming center in this analysis when the analysis was done.

The authors compared the survival for pediatric intensive care unit patients, both medical and surgical, in two different locations. One was Victoria in southeastern Australia; the other was Trent in north central England. Obviously, neither is a third world environment. Australia at the time had established guidelines and a formal regionalization strategy so that patients were regularly, by policy, transferred to PICU environments based upon medical need. In Trent, much as the United States today, patient assignment was driven by a combination of patient (family) and physician wishes, history, and ad hoc decisions rather than a protocol driven link to individual medical need. If you look particularly at the highlighted line that analyzes deaths, you see (on the right) in Victoria that the number of observed and expected deaths was precisely the same. Expected deaths were calculated from a scoring system that assigned a probability of death and whenever children are treated. Anaesthetists must maintain their skills in paediatric resuscitation to the level of advanced paediatric life support or equivalent.

I commented earlier on the subject of a volume outcome relationship in congenital heart surgery and to an uncertain extent, neonatal surgery. What do we, as pediatric surgeons, think about the issue of neonatal surgical volume as it relates to patient outcomes? Dr. Li Ern Chen surveyed the membership of the American Pediatric Surgical Association about a year ago and her results are shown here [24] (Fig. 13). You see that when pediatric surgeons were asked whether higher neonatal surgical volume is associated with better patient outcomes, more than 70% of APSA members either agreed or strongly agreed with that view while fewer than 10% disagreed or strongly disagreed.

Table 5
Guidance on the provision of Paediatric Anaesthesia Services.

- Anaesthesia services for children require specially trained clinical staff together with equipment, facilities and environment.
- The service should be led at all times by consultants who regularly anaesthetize children.
- At all times, there must be adequate skilled, dedicated assistance; assistance for paediatric anaesthesia should be provided by staff specifically trained for the task.
- In a life-threatening emergency where transfer is not feasible, the most senior appropriately experience anaesthetist available should undertake anaesthesia.
- Paediatric resuscitation equipment must be available wherever and whenever children are treated. Anaesthetists must maintain their skills in paediatric resuscitation to the level of advanced paediatric life support or equivalent.
- There should be properly staffed and funded acute pain service that covers the needs of children.
- Neonatal and paediatric high dependency and intensive care services should be available for the type of surgery performed.
- Parents should, wherever possible, be involved in all aspects of care and decisions regarding the management of their children.

Table 6
Frequency of current experience for children’s anaesthetist.

<table>
<thead>
<tr>
<th>Class</th>
<th>Monthly</th>
<th>Weekly</th>
<th>Daily</th>
<th>i.e. Annually</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Infants &lt; 6 months)</td>
<td>X</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 (Children and infants &lt; 3 years)</td>
<td>X</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 (Children &lt; 10 years)</td>
<td>X</td>
<td>300</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When considering the provision of anaesthesia, the Royal College of Anaesthetists recommends that the following areas should be addressed. The goal is to ensure a comprehensive, quality service dedicated to the care of patients and to the education and professional development of staff. The provision of adequate funding to provide the service described should be considered.

Table 7
Annual number of anesthetics | Number of complications per 1000 anesthetics

<table>
<thead>
<tr>
<th>Annual number of anesthetics</th>
<th>Number of complications per 1000 anesthetics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–100</td>
<td>7.0 ± 24.8</td>
</tr>
<tr>
<td>100–200</td>
<td>2.8 ± 10.1</td>
</tr>
<tr>
<td>&gt;200</td>
<td>1.3 ± 4.3</td>
</tr>
</tbody>
</table>

A significant inverse correlation was shown between volume and complication rate in pediatric anesthesia.
time. The authors’ conclusion is, “If Trent is representative of the whole country, there are 453 (200–720) excess deaths a year in the U.K. that are probably due to suboptimal results from paediatric intensive care” [25]. I point out that this was an influential report that I think altered care for these patients in the UK. As I noted earlier, we triage and transfer patients inconsistently in the United States today. Some regions do this well, some not as well. We do not have a structured system. The population of the United States is approximately 5 times that of the UK.

As for the NICU, the American Academy of Pediatrics has published recommendations for resources necessary for pediatric intensive care units, most recently in 2004. Again, these are detailed recommendations regarding resources without a mechanism to verify compliance. Current data demonstrate that regionalization has not been effectively implemented for pediatric critical care in the U.S. despite a formal recommendation in 2000 by the American Academy of Pediatrics and the Society of Critical Care Medicine which concluded that available evidence supported adoption of regionalization [26–29]. For example, Watson et al. in 2002, reviewed the situation and concluded, “unfortunately a growing body of evidence suggests that many hospitalized critically ill children with fatal outcomes in the United States never receive the highest level of care available.”

6. A specialized environment is likely important for (relatively) simple pediatric surgical problems

Most of us here this morning consider intussusception to be a relatively straightforward pediatric surgical problem. Last month, McAteer and colleagues published a population-based analysis of intussusception outcomes in the State of Washington over a ten-year period [30]. Three hundred and twenty-seven children who underwent operative management for intussusception during this period were reviewed. Notably, patients cared for in pediatric hospitals had more severe disease at presentation, yet the likelihood of bowel resection was higher in non-pediatric hospitals. Postoperative complications were more common for patients receiving care in a non-pediatric hospital as well. Likewise, for patients between 0–4 years of age, the cohort presumed to have idiopathic intussusception, the likelihood of bowel resection in a specialized pediatric environment was approximately 20% that of a child treated in a non-pediatric environment.

To consider two common and relatively straightforward childhood surgical problems, appendicitis and pyloric stenosis, McAteer and colleagues also did a Cochrane style review to examine the literature for a link between outcomes and care environment. This was published about 6 months ago in JAMA Pediatrics [31]. For appendicitis, there were 4 relevant studies comparing pediatric surgeons with general surgeons. Of these, none demonstrated a more favorable outcome for general surgeons. With pediatric surgeons, 3 of 4 showed a shorter length of stay, 2 of 4 were associated with lower hospital charges, 1 of 4 demonstrated a lower complication rate and 1 of 4 had lower negative appendectomy rate. An assumption is that when a pediatric surgeon was involved, it was indicative of a more specialized children’s environment. Likewise, 3 studies compared children’s to general hospitals, again looking at appendicitis. None of the 3 favored a general hospital environment for patient clinical outcomes, although financial outcomes were mixed. Two of 3 studies found a longer length of stay at children’s hospitals, 1 of 3 had higher hospital charges at a children’s hospital, 1 of 3 had a lower negative appendectomy rate at a children’s hospital, 1 of 3 had a lower postoperative surgical site infection rate at a children’s hospital, and 2 of 3 had a lower readmission rate to a children’s hospital.

With regard to pyloric stenosis, similar analyses for 3 studies compared the performance of pediatric versus general surgeons. Three of 3 found fewer complications with pediatric surgeons, 2 of 3 demonstrated a shorter length of stay with pediatric surgeons, and 1 of 3 had lower hospital charges with pediatric surgeons. None of the 3 favored general surgeons over pediatric surgeons. Comparing children’s hospitals general hospitals for pyloric stenosis, 2 of the 3
relevant studies found a shorter length of stay at a children’s hospital and 1 of 3 found higher hospital charges. A more recent, yet unpublished analysis by this same group using U.S. national data demonstrated fewer surgical and fewer anesthesia related complications for appendectomy patients under the age of 5 years and for pyloromyotomy patients when these patients were cared for in an urban environment compared to a rural environment. The presumption here is that specialized hospital resources including pediatric providers are more likely to be available in an urban environment.

Taken together, I believe that these recent data suggest that even for relatively simple pediatric surgical problems such as intussusception, pyloric stenosis, and appendicitis in young children, a more specialized pediatric environment is associated with lower morbidity. Fortunately, mortality is sufficiently rare that it is not a discriminating point of analysis.

7. A simple vision

This brings us now to what I believe is a very simple but clear and correct vision - that every child in need of surgical care in North America today will receive care in an environment with resources appropriate to his or her individual need. Furthermore, I believe this is a vision applicable elsewhere. I believe our professional responsibility through the various systems we have, whether in Canada, the United States or elsewhere, is to offer the level of care that we believe is best for all of our patients. The question we should ask is: Where would you take your own child, grandchild, or other friend or family member to obtain optimal surgical care, whether simple or complex? I recognize that this is potentially a disruptive vision, but I firmly believe that it is the right thing for us to advocate.
8. Models exist to define optimal resources/verify implementation and to improve patient outcomes → eg. trauma/cancer/bariatric care

The way in which patients and families select a site of care is clearly different in the United States than in Canada. The Canadian system affords opportunity at the provincial level to direct such decisions administratively. In the United States, of course, we have a unique entrepreneurial system where providers often compete to win patients. I do not envision a time when there will be government directed patient allocation in the U.S. There is considerable variation around the world, of course. Some regions have little or no specialty care available. Even in developed regions such as Western Europe, there are mismatches of resources with patient needs I believe, based on my travels and professional conversations.

For the remainder of my time this morning, I am going to discuss the concept of medical standards implemented by a verification process developed and executed by professionals. To be clear, the organization that has the longest history of such work in the United States is the American College of Surgeons (ACS). For nearly a century, the ACS has developed standards, defined resource requirements and verified the existence of these. Cancer program standards, and what is now our Joint Commission to accredit hospitals, have resulted from these efforts. Beginning in the 1970’s, such a system was developed for trauma centers. More recently other examples including bariatric surgery and breast care centers have also been established.

To focus on the trauma system example, a group of like-minded highly motivated surgeons came together at the ACS and first published a document identifying optimal resource standards for the care of seriously injured patients in 1976. Over the intervening decades, sequential updates have been provided [32]. A system of verification by the ACS was developed to ensure that these standards were met and there is now a voluntary system in place that is national in scope and has been demonstrably effective at improving trauma patient outcomes in the U.S. Although there is considerable variation from state to state, a landmark report in the New England Journal of Medicine by MacKenzie et al. [33] demonstrated the clear benefit of trauma center care on mortality across the United States. To simplify considerably, injured adult patients cared for in the proper environment with optimal resources have a survival advantage of approximately 20–25%. This is highly significant and the impact at a population level clear.

9. A specific proposal to define optimal resources for children’s surgical care

We, and I will talk about “we” momentarily, have developed a specific proposal to define optimal resources for children’s surgical care. The current version of these resource standards, which I consider Version 1.0, is available at www.EAPSA.org and is in press with the Journal of the American College of Surgeons [34]. The proposal itself is too lengthy to examine in detail this morning. However, I do wish to make you aware of our initiative. Briefly, we stratified patients, largely by procedure complexity or patient risk factors, and identified resources based on data and consensus. We grouped these resources into 3 tiers of children’s surgical centers. We have chosen to call these “Basic”, “Advanced” and “Comprehensive” children’s surgical centers at present. We paired resources, mostly people with children’s specific specialty training with patient characteristics that we believe will yield optimal care when properly matched. We defined surgeons, anesthesiologists, radiologists, NICU/PICU capacity, nursing, emergency room and other types of resources in some detail.

10. Where are we now with the optimal resources initiative and where are we going?

To speak now to the question of the process, a Task Force of invited leaders from multiple specialty organizations was convened with the support and participation of the leadership of the Children’s Hospital Association and the American College of Surgeons, meeting first on April 30–May 1, 2012, and next one year later from May 30–31, 2013. The individuals who participated are detailed in the manuscript that I just referenced. It was designed to be a representative but manageable gathering. We did have senior representatives from pediatric surgery, pediatric anesthesia, pediatric neurosurgery, neonatology, pediatric cardiology and others. The proposal has subsequently been reviewed by specialty representatives from other related disciplines and continues to undergo revision based upon their input and participation. It was a consensus process driven by data when possible. Some of the data you have seen today was generated by this group in the interim. Other data are still necessary to assess financial impact, travel burden and manpower needs if such a system is adopted. The intent, as I have said, is to stratify infants and children by need and to define the optimal resources appropriate for their surgical care.

Let me summarize where we are to date:

January 26, 2013 – The APSA Board of Governors approved this concept and proposal.

May 4, 2013 – The APSA members likewise approved the optimal resources document that I referred to.

June 7, 2013 – The Regents of the American College of Surgeons approved this proposal.


October, 2013 – The proposal will be presented to the American Academy of Pediatrics Board. It has been approved by each of the individual Surgical Sections, including Anesthesia.

Between July and September 2013 – Planning and approval of the verification process within the American College of Surgeons has proceeded.

January, 2014 – The Task Force will meet with the American College of Surgeons staff and leadership to convert the principles in the manuscript into a specific verification tool for site visits. This will include the development of a standardized data collection process. I am hopeful that voluntary ACS verification visits can be offered in about 1 year.

Let me offer two additional closing thoughts. I believe personally, and I think from my conversations with many of you at this CAPS meeting, that we do have professional consensus that we can do a better job of seeing that children are cared for in an environment tailored to their individual needs. There is ever more public scrutiny of what we do and this plays out almost daily in the press. I will offer but one well-known relevant example. The subpar performance of the congenital heart surgery program in Bristol in the UK led to a very public outcry, investigation by the press and NHS, and ultimately change mandated by government. I submit to you that this outcome is a failure of the professional community. I know that we can do better. I suggest to you today that we can and should modify our system of care to provide what we know and believe to be best for children. Today’s proposal is a step in that direction.

Lastly, I have no illusions that this will happen overnight or without resistance. It is a journey begun by others long ago but it is ours at present. I asked the APSA membership in May of this year to take a step with me at that meeting and I am hopeful that we can take another here today.
I appreciate your attention. Again, I am honored to be with you in this role today and I look forward to your comments.

References