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Regarding Naomi Burns (DOB 1/7/14)

Dear Mike,

I was happy to review the materials you sent me in this case. These included EMS runs, birth records, St. Joseph Mercy ED reports, Naomi's general pediatric records, the admissions to the UofM in March of 2014 and radiology reports from the UofM.

As you know, Naomi's birth was complicated. Vacuum assisted extraction was unsuccessful and ultimately a C-section had to be done for dysfunctional labor. The child's head circumference at birth was in the 75th %tile. At 2 mos of age, consistent with a birth acquired chronic subdural hemorrhage, her head circumference was at the 90th %tile. The HC chart from the UofM shows a change over a brief time from the 50th %tile to the 90th %tile.

On 3/16/14 Naomi was seen in the St. Joseph Mercy ED because of vomiting after a short fall near a coffee table, during which her father indicated he caught her by the head prior to impact with the floor. The child did have a forehead bruise. Although mom recalls a linear mark and possibly finger mark(s), these were not seen. Naomi was seen again the next day and again discharged. No marks were noted.

The day after that the child was seen in her pediatrician's office and discharged home, but then developed what most likely were seizures. Seizures later were confirmed and treated with phenobarbital. The child had intermittent apnea, decreased responsiveness, bradycardia and acute signs of shock/stress, as well. She was also dehydrated. Her fontanel was noted to be full, despite the dehydration (consistent with the chronic subdural effusion). She had to be intubated and ventilated for a brief time. She was subsequently extubated without event and appeared to be completely neurologically normal. The platelet count at this time was high (>700,000), most likely reactive and possibly related to a re-bleed. The MRI done at this time was read as showing benign enlargement of the subarachnoid spaces. Later the report was amended to indicate that the large extra-axial collections were chronic subdural effusions and that there appeared to be some newer blood, as well.

She was discharged, however, on 3/24/14. By that evening Naomi began having very similar episodes (most likely seizures) and was readmitted. The family also had noticed that her cry had become high-pitched. As with the previous admission, the physical examination showed no external evidence of trauma. After an ophthalmological exam which had been done to look for evidence of metabolic disease showed diffuse multilayered retinal hemorrhages extending out to the periphery, a child abuse work-up followed; appropriately so. The bone survey was negative for old, healing or acute fractures. No C-T scan of the head was done. US of the head showed that the effusions had grown in size. The previous

MRI was re-interpreted. A new one showed some maturation of the newer blood seen in the chronic subdural hemorrhages. Although clotting screening studies were normal, the Von Willebrand work-up raised the issue of a possible bleeding diathesis. Platelet count was even higher (>900,000), again indicating a reactive increase. Repeat testing for metabolic disease was negative.

Naomi again made a complete recovery and appeared neurologically completely normal. Two weeks later a repeat bone survey was again negative.

Given the combination of: old subdural blood; more recent bleeding (subsequent event); the severe retinal hemorrhages outside of the 6 week newborn window; seizures; facial bruising (3/16) in an infant less than 4 mos of age; and a history of a very minor event (3/16) which would not usually be associated with the retinal and subdural hemorrhages; a diagnosis of child abuse was made.

Regarding the **chronic subdural hemorrhages** (effusions), the circumstances of Naomi's birth are an essential consideration. Birth related subdural bleeds are more common after instrumentation assisted deliveries. Repeatedly studies have shown that the incidence of intracranial hemorrhage is consistently increased for forceps and vacuum assisted deliveries. Vacuum extraction was attempted in this case. Researchers have also known for some time that dysfunctional labor is the major risk factor for birth related intracranial hemorrhage. This child's birth was complicated and certainly dysfunctional; ultimately requiring a C-section to deliver the baby. This child had a marked increase in head circumference over the next 2 months. This supports that the child actually acquired her original subdural hemorrhage(s) during her very complicated, vacuum attempt failed, C-section birth.

Once a child has birth acquired subdural hemorrhages which become chronic, they characteristically grow by rebleeding which is often accompanied by seizures. In a child with chronic subdural effusions who develops a rebleed it is often assumed despite the birth history that the new hemorrhage is abusive and the chronic hemorrhage is evidence of prior abuse, thus establishing a pattern of abuse. Things used to help characterize the hemorrhages as abusive are the concomitant presence of long bone or rib fractures (seen in > 50% of abuse related chronic/rebleed subdurals), cutaneous or solid organ injuries, demonstration of cervical injury and retinal hemorrhages. Naomi's bone survey was completely negative as was a repeat survey. She had no cutaneous nor any solid organ injuries. She did have retinal hemorrhages.

Once a birth related chronic subdural develops, especially as it grows, a circumstance known as "**craniocephalic disproportion**" develops in which the space between the brain and the inner table of the skull becomes quite wide. As well, the chronic subdural membrane is porous and leaky. Together these factors predispose the child to further bleeding into that space.

When chronic subdural presents, in our country particularly, especially if there is evidence of multiple episodes of bleeding, there is always the dilemma of a benign explanation vs (recurrent) inflicted abusive head injury. In Naomi's case birth trauma could easily and most likely accounts for the original subdural hemorrhage which went on to become chronic. Re-interpretation of the original MRI certainly implies that she had another episode of bleeding, albeit minor. The presumption, especially if the

chronic subdural or if the acute-on-chronic bleeding is associated with retinal hemorrhages, has always been that the bleeding is from child abuse. However, when a predisposing factor such as cranioccephalic disproportion exists, which it did in Naomi's case, minimal trauma can result in new bleeding; in fact new bleeding may occur spontaneously. An event as minor as a partial fall; or very small distance fall even onto a soft surface; or even simply being caught in a fall could result in re-bleeding under this circumstance.

As stated, rebleeding, for the most part, has been assumed by pediatricians to be secondary to recurrent inflicted trauma; in part because of Pediatrics' focus in making certain that children are protected. It is very clear, however, that rebleeding with chronic subdural hematomas can occur with absolutely minimal trauma and, in fact, can occur spontaneously and asymptotically. MRI studies of these subdural collections, as in Naomi's case, frequently show very large collections, often times with multiple layers of multiple ages and the evidence of chronic membranes within the subdural space. Chronic subdurals enlarge by rebleeding, which happened to Naomi, and can do so without any form of child abuse. As already mentioned, this is especially true because of the distances the veins have to travel (and are subject to stretch) and because the capillaries in the chronic subdural membranes are abnormally weak and porous, cluster-like and predisposed to rupture. As well, the subdural space in these cases is filled with breakdown products which act as potent anticoagulants.

Although it is unlikely that Naomi has clotting abnormality (if she did, her tendency to bleed would be even greater), the issue is still somewhat unresolved. The Von Willebrand disease follow-up has not to my knowledge been completed.

As I indicated, rebleeding and leaking can occur completely spontaneously or from very minor events. The children tend to make full neurological recoveries, because, unless they have stopped breathing for a prolonged period or have suffered from hypotension related to seizures, they do not suffer acute traumatic, hypoxic or ischemic brain injury such as one might see with abusive head trauma. As you might expect, in children who have rebleeding either spontaneously or from the kind of minor trauma that would never otherwise be expected to cause injury, there are no abuse related phenomena such as body bruises or old or new fractures. (Naomi didn't have any of these things, either).

In Naomi's case, however, there are **retinal hemorrhages**. If the retinal hemorrhages are profuse, multilayered and extend to the periphery, they are, under most circumstances, highly specific for abuse. The association between abusive subdural hemorrhage and retinal hemorrhage of any kind is very strong. Naomi has retinal hemorrhages of the type which are considered to be extremely specific for abuse when seen outside the time when birth related hemorrhages could be seen (usually the first 5-6 weeks after birth). Naomi is nine weeks at the time of first presentation. The hemorrhages are multilayered, very numerous and extend to the far periphery.

The above described retinal hemorrhages found beyond 6 weeks of age are almost never seen accidentally.

The exception, however, may be in childhood cases of subdural hemorrhage and cranioccephalic disproportion (which Naomi had). In 1999 Dr. Piatt described a 4 mos old boy whom several people had witnessed fall from a propped position. The child had fresh subdural hemorrhage in the setting of cranioccephalic disproportion. His retinal exam showed profuse bilateral, retinal, pre-retinal and subhyaloid hemorrhages. Dr. Piatt pointed out, from the perspective of a neurosurgeon, that in many familiar clinical situations, retinal hemorrhaging is linked to sudden pressure transients within the cranial cavity. Retinal hemorrhage during intracranial hemorrhage is well recognized and can be in part secondary to the sudden transmission of elevated intracranial pressure. Usually, however, this does not cause profuse multilayered retinal hemorrhaging. However, cranioccephalic disproportion, such as Naomi's, and which Dr. Piatt's patient had, may in Dr. Piatt's opinion impart a special susceptibility. Dr. Piatt speculated that the mechanical properties of the cranium and its contents are abnormal in cases of cranioccephalic disproportion and that the enlarged space may transmit suddenly elevated intracranial pressure more efficiently to the eye and the central retinal vein.

In abuse, the gradation of retinal hemorrhages has been held to correspond to the severity of associated intracranial injury. Naomi, however, had no MRI documented brain parenchymal injury and made a complete neurological recovery. Piatt concluded in his case that: the development of subdural hematoma in an infant with cranioccephalic disproportion might be occasion for unjustified accusations of child abuse when retinal hemorrhages are concomitantly present; and that the idea **in this particular circumstance** that the concomitant presence of retinal hemorrhages reinforces the diagnosis of child abuse may be an incorrect conclusion.

There are 2 alternatives in this case.

In support of abuse, you have:

- 1) Facial bruising in a child < 4 mos of age which is highly suspicious for abuse if there is no clearly acceptable explanation;
- 2) Mixed ages of blood in the subdural effusion which could represent repeated episodes of abuse related bleeding;
- 3) Florid multilayered retinal hemorrhages extending to the periphery which is highly specific for abuse;
- 4) No history of significant trauma beyond birth itself;
- 5) The combination of which points strongly to an interpretation of abuse.

This ignores the things which support an **alternative explanation**:

- 1) There is a reasonable explanation for the facial bruise which was on the forehead; no bruising of any kind was seen during the subsequent admissions for seizures;
- 2) Naomi had an abnormal rate of head growth from the first week of life implying that she had a birth related subdural which became chronic;

- 3) She was born by C-section after a very difficult labor in which vacuum extraction was attempted; both circumstances being associated with much higher rates of birth related subdural bleeding than otherwise;
- 4) Birth related subdurals obviously can go on to become chronic;
- 5) The family was very conscientious in seeking help even before the seizures; they certainly were not trying to hide anything;
- 6) When Naomi's MRI was done, consistent with her rapid recovery, there was no acute brain injury (one might have expected to see acute brain injury in an abused child);
- 7) Naomi's bone surveys were both negative. Bone surveys can be positive > 50 % of the time in abuse related cases of chronic subdural effusions;
- 8) Chronic subdurals can rebleed spontaneously; often with seizures as a manifestation of that process;
- 9) Unlike in abuse where the extent of retinal hemorrhages tends to parallel the severity of underlying brain injury, Naomi made a very rapid and complete recovery;
- 10) Accidental non-abusive retinal hemorrhages, essentially identical to these, have been described in just this circumstance ("craniocephalic disproportion") in which intracranial pressure/ocular dynamics may be considerably different than in normal children; this is the one exception to an otherwise extremely tight relationship between these kind of retinal hemorrhages and abuse;
- 11) The issue of Naomi having a bleeding diathesis, while unlikely, is unresolved.

Thank you. I hope this has been of help.

Sincerely,

Stephen R. Guertin, M.D.