Introduction

Hypertrophic pyloric stenosis (HPS) is one of the most common gastrointestinal disorders during early infancy, with an incidence of 1-2:1000 live births. This condition presents in infants most commonly between the ages of 2 and 8 weeks of life. In HPS, hypertrophy of the circular muscle of the pylorus results in constriction and obstruction of the gastric outlet. Gastric outlet obstruction leads to non-bilious, projectile emesis, loss of hydrochloric acid with the development of hypochloremic, metabolic alkalosis, and dehydration. Surgical myotomy is the primary approach to the management of HPS.

Target Population

Inclusions: These guidelines are intended for use in children less than 3 months of age with signs, symptoms or exam findings suggesting a diagnosis of HPS.

Exclusions: These guidelines are not intended for use in patients with:

- Suspected sepsis
- Bilious vomiting suggesting intestinal obstruction
- History or presence of significant comorbidities or chronic conditions which would alter approaches to care

Epidemiology

The cause of pyloric stenosis is unknown. Genetic, familial, gender, and ethnic origin can influence the incidence rates of HPS. Males outnumber females in every series by a ratio of 4-5:1 (Applegate 1995 [D], Mackay 1986 [D], Poon 1996 [D]). There is a higher risk for developing HPS in offspring of parents with this condition and, in many series, first-born males are frequently encountered (Murtagh 1992 [S]).
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vi. The mobility of the pyloric olive in all 4 directions distinguishes HPS from a retroperitoneal mass.

vii. When palpable, the olive will feel smooth and hard, oblong, and approximately 1.5 – 2.0 centimeters in size.

• Note 2: The ability to palpate the olive varies with the experience and persistence of the examiner and ranges from 40-100% (Murtagh 1992 [S]).

Estimating Dehydration in HPS

1. Dehydration may be encountered in patients with HPS. Estimating dehydration is an important first step in determining optimal approaches to diagnose HPS. Acute body weight changes provide the best measure of dehydration in a young child (Duggan 1996 [C], Gorelick* 1997 [C]). Mucous membrane hydration, capillary refill time (Saavedra 1991 [D]), absence of tears, and alterations in mental status are the next best associated measures. The presence of any three or more of these latter four signs has a sensitivity of 87% and specificity of 82% for detecting a deficit of 5% or more (Duggan 1996 [C], Gorelick* 1997[C]). (See Table 1).

* Population studied was one month to 5 years of age. Other considerations may apply for children less than one month of age.

Laboratory Assessment

1. The assessment of electrolyte status is not routinely indicated in the early diagnosis of HPS. Once a diagnosis is confirmed, it is recommended that the electrolyte status of the patient be checked pre-operatively and any significant abnormalities in electrolytes or hydration status be addressed prior to surgery. The CHMCC Department of Anesthesiology suggests a pre-operative bicarbonate level of #30 meq/L, be achieved before surgical correction is performed (Local expert consensus [E], Bissonnette 1991[S], Habre 1999 [D], Goh 1990 [C], Graham 1993[D]).

• Note 1: Earlier studies indicated that up to 10% of patients with HPS present with electrolyte abnormalities including hypokalemia and hypochloremic alkalosis (Chen 1996 [D], Pappadakis 1999 [D]). More recent studies report fewer metabolic derangements (Poon 1996 [D]).

Referral for Further Evaluation of HPS

1. In children who present with HPS symptoms but are deemed to be well hydrated, factors influencing the next step include the time of day, severity of symptoms and social situation. If the child is well hydrated and the social situation permits, the patient may be scheduled for an elective outpatient radiologic evaluation or direct referral to a pediatric surgeon within 24 hours of this visit. Under these circumstances, parents are instructed to call if signs and symptoms of dehydration develop (Abbas 1999 [D]).

• Note 1: Palpation of an olive by an experienced examiner, such as a pediatric surgeon, may obviate need for a confirmatory imaging study. This is due to the high specificity of positive exam ((Forman 1990 [C,D], Breaux 1986 [D], Macdessi 1993 [D], Godbole 1996 [C], Hulka 1997 [Q], White 1998 [Q]).

2. It is recommended that the infant be referred to the Emergency Department for evaluation and treatment with IV fluids if dehydration is suspected clinically or the social situation warrants more immediate action (Local expert consensus [E]).

Radiologic Assessment

1. The diagnosis of HPS can be made with imaging by an ultrasound exam (US) or fluoroscopic upper gastrointestinal series (UGI). These imaging tests have similar performance in terms of sensitivity and specificity for the diagnosis of HPS (See Table 2). In the absence of a large prospective comparison study with ROC analysis or a meta-analysis of existing studies, neither test can be proved as clearly superior in the diagnosis of HPS. UGI is superior to US in diagnosing some other conditions associated with vomiting in infants, such as gastroesophageal reflux, malrotation, and gastric webs (Cohen 2000[E]). However, sonography has certain advantages over UGI, including the absence of ionizing radiation exposure and lack of oral contrast use which eliminates the risk of barium aspiration or intraperitoneal barium spillage during surgery. This has led to US becoming the standard or preferred initial imaging method when HPS is the most likely diagnosis (Blumhagen 1983 [C & D], Khamapirad 1983 [D], Hayden 1984 [D], Stunden 1986 [C], Weiskittel 1989 [O], Garcia 1990 [S], Rollins 1991 [C], Hernanz-Schulman 1994 [D], Cohen 2000 [E]).
2. A persistent pyloric muscle thickness >3-4mm or pyloric length >15-18 mm in the presence of functional gastric outlet obstruction is generally considered in the diagnostic range for HPS by US. There is not strong agreement in the literature regarding the optimal size threshold for diagnosis. Many studies show pyloric size overlap between HPS and non-HPS cases, and the diagnostic performance of specific size thresholds varies across studies (Haller 1986 [E], Stunden 1986 [C], Mollitt 1987 [D], Lund Kofoed 1988 [C], Blumhagen 1988 [C and D], Westra 1989 [C], Philippin 1989 [D], O’Keefe 1991 [D], Lamki 1993 [C and D], Hernanz-Schulman 1994 [D], Neilson 1994 [D], Godbole 1996 [C], Rohrschneider 1998 [C], Cohen 1998 [D]). The use of smaller diagnostic size thresholds may be more applicable in younger or smaller neonates (Cohen 2000 [E]). With any size cut-off there is a reciprocal relationship of sensitivity and specificity, where a larger size cut-off will increase specificity at the expense of sensitivity, and a smaller size cut-off will increase sensitivity at the expense of specificity. The dynamic evaluation of gastric emptying by real-time US is important, particularly in cases with borderline size measurements (Strauss 1981 [D], Ball 1983 [C], Stunden 1986 [C], Mollitt 1987 [D], Hernanz-Schulman 1994 [D], Neilson 1994 [D], Godbole 1996 [C], Cohen 1998 [D], Rohrschneider 1998 [D]). Many experienced sonologists rely more on a subjective visual impression of the pyloric size and gastric emptying than on pyloric measurements (Hayden 1984 [D], Blumhagen 1986 [E], Westra 1989 [C], Godbole 1996 [C]).

- **Note 1:** An US exam is technically nondiagnostic when the pyloric region is inadequately visualized. This may occur from excessive patient motion or from obscuration or displacement out of the field of view by excessive gastric contents. At the discretion of the sonologist, a nasogastric tube may be placed to empty the stomach and facilitate pyloric visualization. If the US exam remains nondiagnostic due to technical factors, an UGI is suggested.

- **Note 2:** Cases with borderline pyloric size measurements by US may represent pylorospasm or HPS in evolution. Persistent pyloric muscular thickening and functional gastric outlet obstruction suggests HPS. If pyloric muscular thickening and gastric outlet obstruction are transient, pylorospasm is implied (Cohen 1998 [D]).

- **Note 3:** Despite careful attention to pyloric size measurements and pyloric function by real-time US observation, some US exams may be inconclusive, particularly those with borderline size measurements. Patients with an inconclusive US exam may undergo an UGI or may be followed closely clinically with repeated physical exams and/or additional imaging studies as indicated. Follow-up is highly recommended as some of these cases may progress to frank HPS, with reported time periods ranging from a few days to greater than one month (Tunell 1984 [C], Blumhagen 1988 [D], O’Keefe 1991 [D], Lamki 1993 [C and D], Hallam 1995 [D], Godbole 1996 [C], Bergami 1996 [C]).

3. An UGI is favored over US as the most cost-effective initial imaging study when:

a) The clinical presentation of the vomiting infant is atypical for HPS (e.g. bilious emesis, emesis present since birth, patient age extreme) and favors other conditions more amenable to diagnosis by UGI such as GER or malrotation (Olson 1998 [Q], Hulka 1997 [D], Foley 1989 [C], Forman 1990 [C,D]).

b) An UGI is planned if the US is negative (a negative US leading to an UGI does not save the patient radiation exposure and increases the overall cost of imaging (Cohen 2000 [E]).

- **Note 1:** The primary criterion for the diagnosis of HPS by UGI is a narrowed, elongated pyloric channel with pyloric mass effect on the stomach and duodenum. This may produce a string sign, double tract sign, beak sign, or pyloric teat sign. Ancillary findings of HPS on UGI are gastric hyperperistalsis, large volume gastric residue, and delayed gastric emptying (Shopfner 1964 [D], Shuman 1967 [D], Cremin 1968 [D]).

- **Note 2:** As with US, some UGI studies may be inconclusive. These cases may undergo an US or be followed closely clinically with repeated physical exams and/or additional imaging studies as indicated.

**Diagnostic Algorithm**

See Figure 1.

**Surgical Correction:**

HPS is corrected surgically by Ramstedt pyloromyotomy. The pylorus may be accessed by various incision techniques including transverse right upper quadrant,
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Circumumbilical, and laproscopic. All methods are considered acceptable practice with minimal differences in outcomes noted (Hingston 1996 [D], Tan 1986 [C], Poli-Merol 1996 [C], Leinwand 1999 [D], Fujimoto 1999 [C], Fitzgerald 1990 [D]).

Anesthetic Management

1. Infants with HPS have a functional gastric outlet obstruction that may place them at a greater risk for aspiration of gastric contents during induction of anesthesia (Cook-Sather 1998 [E]). Regardless of whether the stomach contents were aspirated prior to the infant’s arrival in the operating theater, it is recommended that precautions be taken to prevent pulmonary aspiration. These maneuvers include oral/nasogastric suction prior to induction of anesthesia and maintaining cricoid pressure (Sellick’s maneuver) during induction of anesthesia (Bissonnette 1991 [S]).

Pain Management

1. Pain management is important for optimal patient outcomes. It is recommended that pain be routinely assessed using standard age appropriate scales (Salentera 1999 [C], AHCPR Guidelines 1992 [E]).

2. It is recommended that the Neonatal Infant Pain Scale be utilized for pain assessment.

Note 1: Valuable information regarding pain management may also be obtained through the measurement of physiologic changes, behavioral observation, and caregiver/parental input (Finley 1998 [S]).

3. It is recommended that the wound be infiltrated with a local anesthetic (i.e. bupivacaine 0.125% up to 1ml/kg) at the conclusion of the surgical procedure. Wound infiltration with local anesthetic has been shown to decrease postoperative analgesic requirements (Habre 1999 [D]).

4. Further analgesia, if necessary, may be accomplished via the administration of acetaminophen (15 mg/kg/dose every 4-6 hours. Not to exceed 5 doses in 24 hours.) (Bissonnette 1991 [S], Habre 1999 [D]). Use of opioids may potentiate the risk of respiratory depression in infants undergoing pyloromyotomy (Habre 1999 [D]). Therefore, it is recommended that narcotics not be administered in the routine post-operative pain management of these infants.

Surgical Site Infection Prophylaxis

1. It is recommended that one dose of Cefazolin, 25 mg/kilogram of body weight, be used to decrease the risk of surgical site infection in all patients. In the event of penicillin allergy, it is recommended that Clindamycin, 10 mg/kilogram of body weight, be the alternative antibiotic of choice.

Note 1: Staphylococcus aureus is the most common organism associated with wound infections in patients who have undergone pyloromyotomy (Rao 1989 [D], Mangram 1999 [E]).

2. To assure adequate blood level at the time of incision, it is recommended that antibiotics be given approximately 30 minutes prior to surgery (Mangram 1999 [E], Anonymous 1997 [S]). Therefore, it is recommended that prophylactic antibiotics be given in the perioperative care before induction and the practice of giving antibiotics “on call to the OR” be discouraged as delays in patient transport or schedule changes may result in suboptimal blood and tissue levels (Page 1993 [S], Silver 1996 [D]).

Note 1: For cephalosporins, adequate blood levels are achieved and sustained for 3-4 hours. If the interval between antibiotic administration and closure of the surgical incision is greater than 4 hours, the administration of an additional dose may be considered (Mangram 1999 [E]).

Note 2: Although rates of infection appear to be higher in the umbilical route, the administration of antibiotics reduced the risk of infection in both groups (Leinwand 2000 [D]).

Feeding Advancement

1. Vomiting following pyloromyotomy is usually self limiting. Although frequency of vomiting is related to type of feeding regimen, duration is independent of the timetable or composition of post-operative dietary regimen (Carpenter 1999 [D], Georgeoson 1993 [D], Gollin 2000 [D], Wheeler 1990 [C]). It is recommended that following pyloromyotomy, infants be fed early and with regular formula or breast milk.

Note 1: The composition of feeding, and the rate of advancement (Georgeoson 1993 [D], Leinwand 2000 [D], Gollin 2000 [D]) may affect the incidence or severity of vomiting post-regimen, but ultimately does not affect time to full

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feedings, discharge or post operative weight gain (Foster 1989 [D]). (See table 3).

- **Note 2:** Duration of post-procedure vomiting is variable, with reports of 3.5% to 24% of infants with continued emesis more than 48 hours after surgery (Carpenter 1999 [D], Scharli 1968 [C], Wheeler 1990 [C]).

- **Note 3:** The most significant predictor of post-operative emesis is the duration and severity of pre-operative vomiting and is frequently manifested by electrolyte abnormalities (Gollin 2000 [D]).

- **Note 4:** Postoperatively, infants may be fed volumes based on feedings taken pre-operatively (Local expert consensus [E]).

**Discharge Criteria**

1. **Otherwise healthy infants may be discharged once they have tolerated two to three full feedings and/or at the discretion of the Health Care Provider** (Carpenter 1999 [D]). Infants with significant pre-operative vomiting, severe electrolyte imbalance, or malnutrition may need a longer period of recovery.

2. **Counseling of parents regarding post-operative emesis, assessment of hydration status, and signs and symptoms of infection are essential components of patient/family education** (Local expert consensus [E]).
FIGURE 1.
Diagnostic Algorithm for Hypertrophic Pyloric Stenosis

* During off hours when an experienced sonographer is less readily available, an UGI may also be performed as an initial study.
TABLE 1. Physical Parameters Associated with Degree of Dehydration

1). Dehydration is usually quantitated based on the % of total body weight loss.

2). A weight loss of less than 3-5% can be difficult to discern clinically.

3). Determining weight gain following rehydration is often the only way to assess the degree of actual dehydration that existed at onset of therapies.

4). Any 3 of the first four parameters in this table predict dehydration of >5%, with a sensitivity of 87% and specificity of 82% (Duggan, 1996, Gorelick 1997).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mild (&lt;6%)</th>
<th>Moderate (6-9%)</th>
<th>Severe (&gt;9%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUCOUS MEMBRANES</td>
<td>Slightly dry</td>
<td>Dry</td>
<td>Dry</td>
</tr>
<tr>
<td>EXTREMITIES</td>
<td>Warm, good refill</td>
<td>Delayed refill</td>
<td>Mottled, poor refill</td>
</tr>
<tr>
<td>TEARS</td>
<td>Normal</td>
<td>Normal to absent</td>
<td>Absent</td>
</tr>
<tr>
<td>MENTAL STATUS</td>
<td>Normal</td>
<td>Normal to listless</td>
<td>Normal to Coma</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal/decrease</td>
</tr>
<tr>
<td>Pulse “quality”</td>
<td>Normal</td>
<td>Normal/ decrease?</td>
<td>Moderate decrease</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>Normal</td>
<td>Increased</td>
<td>Increase or decrease</td>
</tr>
<tr>
<td>Skin Turgor</td>
<td>Normal</td>
<td>Decreased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Fontanel</td>
<td>Normal</td>
<td>Sunken</td>
<td>Sunken</td>
</tr>
<tr>
<td>Eyes</td>
<td>Normal</td>
<td>Sunken</td>
<td>Deeply sunken</td>
</tr>
<tr>
<td>Urine Output</td>
<td>Slight decrease</td>
<td>&lt; 1ml/kg/hr</td>
<td>&lt; 1ml/kg/hr</td>
</tr>
<tr>
<td>Thirst</td>
<td>Slight increase</td>
<td>Moderate increase</td>
<td>May be unresponsive</td>
</tr>
</tbody>
</table>
Table 2: Diagnostic Performance of Imaging Studies for HPS

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Modality</th>
<th>Exams</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
<th>PPV</th>
<th>NPV</th>
<th>HPS Prevalence</th>
<th>Diagnostic Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shopfner</td>
<td>1964</td>
<td>UGI</td>
<td>70</td>
<td>84%*</td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baghdassarian**</td>
<td>1965</td>
<td>UGI</td>
<td>30</td>
<td>100%</td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shuman</td>
<td>1967</td>
<td>UGI</td>
<td>46</td>
<td>96%</td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cremin</td>
<td>1968</td>
<td>UGI</td>
<td>27</td>
<td></td>
<td>89%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breaux**</td>
<td>1986</td>
<td>UGI</td>
<td>137</td>
<td>97%</td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forman</td>
<td>1990</td>
<td>UGI</td>
<td>35</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>34%</td>
<td></td>
</tr>
<tr>
<td>Huddy</td>
<td>1991</td>
<td>UGI</td>
<td>9</td>
<td>100%</td>
<td>75%</td>
<td>89%</td>
<td>83%</td>
<td>100%</td>
<td>56%</td>
<td></td>
</tr>
<tr>
<td>Strauss</td>
<td>1981</td>
<td>US</td>
<td>20</td>
<td>100%</td>
<td>80%</td>
<td>95%</td>
<td>94%</td>
<td>100%</td>
<td>75%</td>
<td>PD 1.5 cm</td>
</tr>
<tr>
<td>Blumhagen</td>
<td>1981</td>
<td>US</td>
<td>35</td>
<td>91%</td>
<td>100%</td>
<td>94%</td>
<td>100%</td>
<td>86%</td>
<td>66%</td>
<td>PMT 4 mm</td>
</tr>
<tr>
<td>Ball</td>
<td>1983</td>
<td>US</td>
<td>27</td>
<td>80%</td>
<td>100%</td>
<td>89%</td>
<td>100%</td>
<td>80%</td>
<td>56%</td>
<td>PD 1.5 cm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>27</td>
<td>93%</td>
<td>100%</td>
<td>96%</td>
<td>100%</td>
<td>92%</td>
<td>56%</td>
<td>PMT 4 mm</td>
</tr>
<tr>
<td>Pilling</td>
<td>1983</td>
<td>US</td>
<td>55</td>
<td>81%</td>
<td>100%</td>
<td>89%</td>
<td>100%</td>
<td>79%</td>
<td>58%</td>
<td>PD 1.5 cm</td>
</tr>
<tr>
<td>Khamapirad</td>
<td>1983</td>
<td>US</td>
<td>30</td>
<td>100%</td>
<td>86%</td>
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<td>89%</td>
<td>100%</td>
<td>53%</td>
<td>PD 1 cm</td>
</tr>
<tr>
<td>Blumhagen</td>
<td>1983</td>
<td>US</td>
<td>169</td>
<td>92%</td>
<td>100%</td>
<td>96%</td>
<td>100%</td>
<td>92%</td>
<td>55%</td>
<td>PMT 4 mm</td>
</tr>
<tr>
<td>Wilson**</td>
<td>1984</td>
<td>US</td>
<td>50</td>
<td>52%</td>
<td>100%</td>
<td>72%</td>
<td>100%</td>
<td>60%</td>
<td>58%</td>
<td>PD 1.5 cm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50</td>
<td>93%</td>
<td>90%</td>
<td>92%</td>
<td>93%</td>
<td>90%</td>
<td>58%</td>
<td>PMT 4 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>33</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>48%</td>
<td>PML 2 cm</td>
</tr>
<tr>
<td>Dell’Agnola</td>
<td>1984</td>
<td>US</td>
<td>91</td>
<td>95%</td>
<td>100%</td>
<td>98%</td>
<td>100%</td>
<td>96%</td>
<td>44%</td>
<td>PML 1.9 cm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>91</td>
<td>93%</td>
<td>90%</td>
<td>91%</td>
<td>88%</td>
<td>94%</td>
<td>44%</td>
<td>PMT 4 mm</td>
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<td></td>
<td></td>
<td></td>
<td>91</td>
<td>80%</td>
<td>96%</td>
<td>89%</td>
<td>94%</td>
<td>86%</td>
<td>44%</td>
<td>PD 1.3 cm</td>
</tr>
<tr>
<td>Studden</td>
<td>1986</td>
<td>US</td>
<td>200</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>56%</td>
<td>PCL 16 mm</td>
</tr>
<tr>
<td>Mollitt</td>
<td>1987</td>
<td>US</td>
<td>73</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>42%</td>
<td>PMT 4 mm, PD 13 mm, PL 17 mm</td>
</tr>
<tr>
<td>Carver</td>
<td>1988</td>
<td>US</td>
<td>39</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>51%</td>
<td>PMI 0.4</td>
</tr>
<tr>
<td>Blumhagen</td>
<td>1988</td>
<td>US</td>
<td>326</td>
<td>98%</td>
<td>100%</td>
<td>99%</td>
<td>100%</td>
<td>99%</td>
<td>34%</td>
<td>PMT 4 mm</td>
</tr>
<tr>
<td>Westra</td>
<td>1989</td>
<td>US</td>
<td>75</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>29%</td>
<td>PV 1.4 mL</td>
</tr>
<tr>
<td>Philippin</td>
<td>1989</td>
<td>US</td>
<td>157</td>
<td>77%</td>
<td>80%</td>
<td>84%</td>
<td>98%</td>
<td>100%</td>
<td>96%</td>
<td>PD 14 mm, PCL 18 mm, PMT 4 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>157</td>
<td>80%</td>
<td>84%</td>
<td>98%</td>
<td>100%</td>
<td>96%</td>
<td>90%</td>
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</tr>
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<td>157</td>
<td>80%</td>
<td>84%</td>
<td>98%</td>
<td>100%</td>
<td>96%</td>
<td>90%</td>
<td></td>
</tr>
<tr>
<td>Forman</td>
<td>1990</td>
<td>US</td>
<td>41</td>
<td>89%</td>
<td>100%</td>
<td>96%</td>
<td>100%</td>
<td>92%</td>
<td>44%</td>
<td>PMT 4 mm or PL 16 mm</td>
</tr>
<tr>
<td>Rollins</td>
<td>1991</td>
<td>US</td>
<td>100</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>44%</td>
<td>PMT 4mm or PD 15 mm</td>
</tr>
<tr>
<td>Hermann-Schulman</td>
<td>1994</td>
<td>US</td>
<td>150</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>44%</td>
<td>PMT 3 mm</td>
</tr>
<tr>
<td>Neilson</td>
<td>1994</td>
<td>US</td>
<td>147</td>
<td>97%</td>
<td>99%</td>
<td>98%</td>
<td>99%</td>
<td>98%</td>
<td>46%</td>
<td>PCL 16 mm, PD 11 mm, PMT 2.5 mm</td>
</tr>
<tr>
<td>Godbole</td>
<td>1996</td>
<td>US</td>
<td>127</td>
<td>99%</td>
<td>100%</td>
<td>99%</td>
<td>100%</td>
<td>98%</td>
<td>65%</td>
<td>PMI &gt; 0.46</td>
</tr>
<tr>
<td>Rohrschneider</td>
<td>1998</td>
<td>US</td>
<td>85</td>
<td>100%</td>
<td>96%</td>
<td>94%</td>
<td>92%</td>
<td></td>
<td>40%</td>
<td>PR 0.27</td>
</tr>
</tbody>
</table>

* Cited in article text as accuracy. ** Non-diagnostic studies excluded from analysis.

The studies abstracted in Table 2 are a subset of numerous publications and are chosen to be representative of the diagnostic performance of UGI and US for HPS. The studies are variably limited by sample size and design. The statistics are as cited by the references; otherwise, they are calculated from 2x2 contingency tables derived from the raw data provided in the references.

PMT = Pyloric Muscle Thickness  PML = Pyloric Muscle Length  PCL = Pyloric Channel Length  PL = Pyloric Length  PD = Pyloric Diameter  PV = Pyloric Volume  PMI = Pyloric Muscle Index  PR = Pyloric Ratio  PPV = Positive Predictive Value  NPV = Negative Predictive Value
### Table 3. Comparison of Feeding Regimens on Post-Op Vomiting

<table>
<thead>
<tr>
<th>Composition</th>
<th>Rate</th>
<th>Length NPO</th>
<th>Reference</th>
<th>Vomiting</th>
</tr>
</thead>
<tbody>
<tr>
<td>D5W 1/2 strength formula</td>
<td>12 feedings – odd # feeds – 15cc sterile water; even # feeds 4 cc sterile water +2 ml formula. n=feeding #. The 2nd feed comes 4h after the first, then q2h x 2 then; q1.5 hrs x 8. Then ad lib.</td>
<td>Overnight &gt;10 hrs</td>
<td>Georgeson et al, 1993</td>
<td>29%</td>
</tr>
<tr>
<td>FS formula</td>
<td>Same schedule as above</td>
<td>6-8 hrs</td>
<td></td>
<td>35%</td>
</tr>
<tr>
<td>Pedialyte 1/2 strength formula</td>
<td>2 feeding*</td>
<td>6 hrs</td>
<td></td>
<td>55%</td>
</tr>
<tr>
<td>FS formula</td>
<td>3 feedings*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedialyte FS formula</td>
<td>2 feeding*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>*advancing 15-30cc with each feeding, starting at 15cc with each set.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30cc q1h x 6</td>
<td>6 hrs</td>
<td>Gollin et al, 2000</td>
<td>54%</td>
</tr>
<tr>
<td></td>
<td>30cc q1h x 6 then ad lib</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedialyte 1/2 strength formula</td>
<td>Advance q3 hrs</td>
<td>6 hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full strength Formula</td>
<td>15 ml x 1; 30 ml x 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 ml x 1; 60 ml x 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>60 ml x 1; 75-90 ml; ad lib</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedialyte 1/2 strength formula</td>
<td>Advance q2h</td>
<td>6 hours</td>
<td></td>
<td>48%</td>
</tr>
<tr>
<td>FS formula</td>
<td>30 ml x 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 ml x 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS formula</td>
<td>45 ml x 4; 60 ml x 4; 75-90 ml x 3 h</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D5W 1/4 strength formula</td>
<td>Advance q2h</td>
<td>1 hour</td>
<td></td>
<td>50%</td>
</tr>
<tr>
<td>1/2 strength formula</td>
<td>5 ml; 1 hr later</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2 strength formula</td>
<td>10 ml 1 hr later</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2 strength formula</td>
<td>15 ml; then advancing to full feeds in 24 hrs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/3 strength formula</td>
<td>on Day 2</td>
<td>6 hours</td>
<td>Leahy &amp; Fitzgerald 1982</td>
<td>73%</td>
</tr>
<tr>
<td>full strength</td>
<td>on Day 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>on Day 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D5W 1/4 strength formula</td>
<td>Advance q3h</td>
<td>4 hours</td>
<td>Turnock &amp; Rangecroft 1991</td>
<td>78%</td>
</tr>
<tr>
<td>1/2 strength formula</td>
<td>5cc D5W, 5cc 1/2 str. Milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2 strength formula</td>
<td>10cc D5W; 10cc 1/2 str. Milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2 strength formula</td>
<td>15cc D5W; 15cc 1/2 str. Milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2 strength formula</td>
<td>25 cc D5W; 25cc 1/2 str. Milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2 strength formula</td>
<td>35cc D5W; 25cc 1/2 str milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2 strength formula</td>
<td>45cc D5W; 45 cc 1/2 str. Milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2 strength formula</td>
<td>FS milk ad lib q3-4 hrs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D5W 1/2 str. Milk FS milk</td>
<td>Advance q3h</td>
<td>18 hours</td>
<td></td>
<td>62%</td>
</tr>
<tr>
<td>ad lib q3-4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D5W 1/2 strength feed</td>
<td>5ml q1h x 4; 10ml q1h x 3</td>
<td>4 hours</td>
<td>Wheeler et al, 1990</td>
<td>78%</td>
</tr>
<tr>
<td>3/4 strength feed FS feed</td>
<td>10ml q1h x 3; then q2hrs give 15ml x 3; 30 ml x 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 ml x 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 ml x 2; 45 ml x 2; 60 ml x 2; 75ml x 2; then ad lib</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D5W FS feed</td>
<td>5ml q1h x 4; 10ml q1h x 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS Feed</td>
<td>10ml q1h x 3; then q2hrs give 15ml x 3; 30 ml x 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 ml x 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 ml x 2; 45 ml x 2; 60 ml x 2; 75ml x 2; then ad lib</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS Feed</td>
<td>40 ml q4h x 1</td>
<td>4 hrs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ad lib</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
REFERENCES

(Note: Some references included in this listing are not cited in the guidelines and are included for those interested in pursuing a further in-depth review of these subjects.)

not at risk for postoperative apnea. Staff of Sutter Community Hospitals Sleep Disorders Center Pediatr Pulmonol. 27:278-81.


The process by which this guideline was developed is documented in the Guideline Development Process Manual; a Team Binder maintains minutes and other relevant development materials. The recommendations contained in this guideline were formulated by an interdisciplinary working group which performed systematic and critical literature reviews, using the grading scale that follows, and examined current local clinical practices.

To select evidence for critical appraisal by the group for the update of this guideline, the Medline, EmBase, CINAHL, and the Cochrane databases were searched. Evidence from 2000 and before was verified for inclusion in the guidelines. Evidence from January 2001 to January 2007 was reviewed to generate an unrefined, “combined evidence” database using a search strategy focused on answering clinical questions relevant to hypertrophic pyloric stenosis, employing a combination of Boolean searching on human-indexed thesaurus terms (e.g., MeSH headings using an OVID MedLine interface) and “natural language” searching on keywords in the title, abstract, and indexing terms. The citations were reduced by eliminating duplicates, non-English articles, and adult articles. The resulting titles, abstracts, and full text articles were reviewed by a methodologist to eliminate low quality and irrelevant citations. During the course of the guideline development, additional clinical questions were generated and subjected to the search process, and some relevant review articles were identified. December, 2000 was the last date for which literature was reviewed for the previous version of this guideline. The details of that review strategy are not documented. However, all previous citations were reviewed for appropriateness to this revision.

Appropriate companion documents have been developed to assist in the effective dissemination and implementation of the guideline. Experience with the implementation of earlier publications of this guideline has provided learnings which have been incorporated into this revision. Once the guideline has been in place for four years, the development team reconvenes to explore the continued validity of the guideline. This phase can be initiated at any point that evidence indicates a critical change is needed.

Recommendations have been formulated by a consensus process directed by best evidence, patient and family preference and clinical expertise. During formulation of these recommendations, the team members have remained cognizant of controversies and disagreements over the management of these patients. They have tried to resolve controversial issues by consensus where possible and, when not possible, to offer optional approaches to care in the form of information that includes best supporting evidence of efficacy for alternative choices.

The guidelines have been reviewed and approved by clinical experts not involved in the development process, senior management, Risk Management & Corporate Compliance, other appropriate hospital committees, and other individuals as appropriate to their intended purposes. The guideline was developed without external funding. All Team Members and Clinical Effectiveness support staff listed have declared whether they have any conflict of interest and none were identified.

Copies of this Evidence-based Care Guideline (EBCG) and its companion documents are available online and may be distributed by any organization for the global purpose of improving child health outcomes. Website address:
Examples of approved uses of the EBCG include the following:

- copies may be provided to anyone involved in the organization’s process for developing and implementing evidence-based care guidelines;
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Notification of CCHMC at HPCEInfo@cchmc.org for any EBCG, or its companion documents, adopted, adapted, implemented or hyperlinked by the organization is appreciated.

**Important Information**

**NOTE:** These recommendations result from review of literature and practices current at the time of their formulation. This guideline does not preclude using care modalities proven efficacious in studies published subsequent to the current revision of this document. This document is not intended to impose standards of care preventing selective variances from the recommendations to meet the specific and unique requirements of individual patients. Adherence to this guideline is voluntary. The physician in light of the individual circumstances presented by the patient must make the ultimate judgment regarding the priority of any specific procedure.

Additionally for more information about CCHMC guidelines and the guideline development process, contact the Health Policy & Clinical Effectiveness office at: 513-636-2501 or HPCEInfo@cchmc.org.