THE ROLE OF SURGERY IN WEANING PATIENTS FROM HOME PARENTERAL SUPPORT – A COHORT STUDY

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ABSTRACT

Background: Some patients with intestinal failure requiring Home Parenteral Support (HPS) may be weaned. This study considers all abdominal surgery in a cohort of HPS patients over 25 years. The aim was to identify how many patients can be weaned from HPS and by what means, and to identify what makes weaning more likely.

Methods: A prospectively collected database of HPS patients to December 2018 was analysed for outcomes of care.

Results: At five years 56% of 205 patients remained on HPS. Fifty-eight patients(28%) who had 68 operations, stopped HPS after surgery.

Patients stopping HPS had longer median final small bowel length (155cm; range 45-350cm) and were more likely to have colon in circuit (84%) than patients who had reconstructive surgery but did not stop HPS (median small bowel length 50cm; range 15-135cm; 50% colon in circuit). The median period between HPS discharge and reconstructive surgery was 238 days. There were no deaths but 18 Clavien-Dindo Grade 3/4 complications within 30days. 90% of patients who stopped HPS survived 5 years from the start of HPS in comparison to 53% of those who remained on HPS.

Conclusions: No previous study has examined surgery in an entire cohort of HPS patients. More than one quarter of HPS patients can be weaned after reconstructive surgery. The length of bowel available for recruitment at surgery is the main determinant of ability to stop HPS. The possibility of reconstruction should be considered, since patients who stop HPS appear to have a survival advantage.

KEYWORDS

Intestinal failure

Home parenteral support

Reconstructive surgery

What does this paper add to the literature?

Patients with intestinal failure require intravenous supplements (Home Parenteral Support HPS). This paper follows a cohort of 205 patients with intestinal failure and shows that reconstructive surgery allowed 58 patients to stop HPS. At five years HPS dependence was 56%.Patients who weaned from HPS had a significant survival advantage.

INTRODUCTION

By definition intestinal failure necessitates parenteral support, either with intravenous nutrition or intravenous fluids. When Home Parenteral Support (HPS) was developed in the 1970's [1] it was seen typically as a treatment for young patients with severe Crohn's disease and short bowel syndrome who would be on HPS for life. In recent years HPS has been used in a wider variety of patients and conditions and chronic intestinal failure requiring HPS has been categorised as Type III intestinal failure which may be reversible or irreversible. However HPS carries significant cost, risk and inconvenience. Weaning from HPS may be achieved by surgery to reduce gastrointestinal losses or recruit dormant intestinal absorptive capacity. At Glasgow Royal Infirmary, over the past quarter century, a policy has been pursued of proactive selection of HPS patients for surgery designed to remove their HPS reliance.

The present study aimed to identify how many patients could be weaned from HPS, which sub-group of HPS patients should be considered for surgery, what surgical interventions are beneficial and what outcome patients might expect.

METHODS

Since 1998, data about adult HPS patients in Glasgow Royal Infirmary have been collected on a prospective basis in an Access database which is updated at every inpatient or outpatient episode of care. Nine patients who started HPS prior to the database had their data included retrospectively when the database commenced (three started between 1993 and 1998, the others prior to 1993).

We have examined the data from this source to December 2018. Caldicott guardian approval was obtained. Patients were aware that their data were being collected and examined for outcomes. The study was registered retrospectively at www.researchregistry.com (UID researchregistry6831). The study complied with the STROCSS guidelines [2]. In total 217 patients had records available on the database. Four patients were excluded completely from analysis as they had been started on HPS in other hospitals and had significant missing data.

The majority of patients whose intestinal failure care takes place in Glasgow Royal Infirmary come from Greater Glasgow and Clyde Health Board catchment area. Patients from other Health Boards constituted approximately one third of patients throughout this period

Patients were transferred to Glasgow Royal Infirmary following referral. Following control of acute intestinal failure, medical management of short gut was optimised by the multidisciplinary nutrition support team prior to instituting HPS. If it was felt that the patient required home parenteral support, appropriate venous access, suitable intravenous prescription and training was instituted. The majority of patients had tunnelled Hickman or Broviac catheters inserted, with a small number using implanted ports. Intravenous electrolytes only were appropriate for a few patients who were included with those requiring nutritional supplements as the management is the same and some patients moved from one formulation to the other. The majority of patients were trained to self-manage their HPS by hospital specialist nutrition nurses, some with the aid of relatives. A few patients had district nurse visits to connect and disconnect their infusions. Once stable, the patients were discharged home.

From 2000 to 2012, there was a Managed Clinical Network for HPS in Scotland [3] and from 2006 a homecare service for supply of intravenous solutions, hardware, ancillaries and some nursing services has been commissioned by NHS National Procurement Scotland. Patients were followed up regularly in a multidisciplinary outpatient clinic. Open access to phone the ward at Glasgow Royal Infirmary was arranged for emergencies and patients were admitted directly to the ward if needed.

At each clinic appointment, consideration was given to the possibility of surgery to reverse the intestinal failure. Any patient with a length of de-functioned bowel was considered eligible. Operation might entail laparotomy and re-anastomosis of bowel, or laparotomy for obstruction or fistula. Absolute contra-indications were absence of recruitable gut, patient refusal of surgery, palliative care for end-stage disease and severely compromised patient fitness.

The aim was to improve both nutritional status and mental and physical fitness as much as possible before operation. Any other medical problems were addressed, including treatment of underlying disease such as Crohn's disease. Once the patient was judged fit enough for surgery the anatomy of the gastrointestinal tract and abdominal wall was assessed by a combination of clinical examination, CT scan and water soluble contrast studies. There was extensive discussion with the patient of the risks and benefits of operation and preoperative anaesthetic assessment was undertaken. Surgical procedures were performed by the consultant surgeons in the intestinal failure team, with involvement of the original surgeons if they wished and other specialities if needed. Generous amounts of theatre time were allowed for these cases. Single layer interrupted bowel anastomosis was performed using polyglactin 910 (Vicryl ™ Ethicon). If the procedure necessitated either multiple bowel anastomoses or

high risk anastomoses (eg active Crohn's disease, relatively ischaemic bowel) a proximal loop jejunostomy was performed and closed a few months later after further contrast studies.

From our prospectively collected database, data were collated for age, sex, health board of residence, underlying disease, indication for HPS and whether HPS followed operation or followed unpredicted post-operative complications. Underlying disease described the pathological process causing the patient's illness. "Other" underlying disease included a variety of pathology, including diverticular disease, complex abdominal wall hernias and mucosal disease. Indication for HPS described the mechanism of intestinal failure rather than the underlying disease. HPS following operation was defined as HPS following operation or operative complication during the same admission period as the start of HPS. The admission when HPS was started was defined as the index admission. HPS following post-operative complication was defined as occurring in patients who had unpredicted surgical complications after operation (eg anastomotic leak, peritonitis or fistula) which led to the requirement for HPS. Short gut which was predictable at the time of operation (eg due to resection for ischaemia) was not included as a post-operative complication. Cause of death recorded on the database had been established from the nutrition multidisciplinary team and the consultant treating the patient at the time of death.. The details of any abdominal operation following commencement of HPS were recorded with any complications requiring radiological or surgical intervention. Patients treated palliatively were defined as those in whom cancer was not curable. Other patients had intestinal failure following treatment for malignancy which was curative. This included some patients with post-operative complications and others in whom resection of neuroendocrine tumour or sarcoma or emergency resection had left only a short length of bowel in circuit.

With regard to survival and HPS dependence, six other patients were excluded from analysis as they had been started on HPS prior to 1993 and we have no records of the other patients from this period. . They had been started on HPN prior to 1993 and we have no records of other patients from this period. Including only the survivors would skew the results. Two patients transferred from paediatric care were also excluded from this analysis. This left 205 patients. Survival was compared between two groups of patients: 121 patients who remained on HPS either at the time of death or at the end of the study period on 31 December 2018 and 58 patients who stopped HPS after surgery. HPS dependence was assessed for 187 non palliative patients. With regard to reconstructive surgery we analysed patients in three groups. Group A had no abdominal surgery after they were started on HPS.

Group B had surgery to reconstruct the gastrointestinal tract but this did not result in stopping HPS. Group C had surgery to reconstruct the gastrointestinal tract which did result in stopping HPS. Figure 3 shows the division of patients into these groups. Comparisons between the groups excluded the two patients who had transplants.

Data was exported in Excel spreadsheets as appropriate. Descriptive statistics were reported as median and range. Kruskal Wallis test was used to compare numerical data. Chi squared+/- Yates correction or Fischer's exact test was used to compare categorical data (https://www.socscistatistics.com). Kaplan Meier curves were drawn for survival and HPS dependence.

The changes which occurred in our HPS practice and more general outcomes in this group have been previously reported[4]. The incidence of catheter related complications was reported up till 2017[5].

RESULTS

Two hundred and five patients were included in the study. The characteristics of these patients are shown in Table 1.

Table 2 shows outcome at 31 December 2018. Fifty-eight patients stopped HPS after surgery: two after bowel transplants; fifty-six after reconstructive surgery. HPS dependence is shown in Figure 1. Table 3 shows the progress of the patients towards surgery.

The median number of days between discharge on HPS and reconstructive surgery (excluding transplants) was 238 (range 75-1440). All patients had home parenteral nutrition or intravenous fluids. One patient also had distal enteral feeding during this period.

Table 4 shows patient characteristics with regard to surgery after HPS commenced. With regard to reconstructive surgery we analysed patients in three groups. Group A had no abdominal surgery after they were started on HPS. Group B had surgery to reconstruct the gastrointestinal tract but this did not result in stopping HPS. Group C had surgery to reconstruct the gastrointestinal tract which did result in stopping HPS. There were no significant differences between the groups B and C in sex ratio, age, small bowel length at discharge on HPS, underlying disease or indication for HPS. Patients who had any GI reconstructive surgery while on HPS (groups B and C) were somewhat younger (median age at discharge 52 years; range 15-82) compared to those who did not have any surgery

(Group A: median age 57; range 19-85; p=0.049) and slightly less likely to have other illness recorded on the database (29% vs 44%) although the latter did not reach statistical significance (Chi p=0.07).

Patients who stopped HPS after surgery (Group C) had a median final small bowel length significantly longer than those who did not stop (Group B) (p=0.00001). Those who stopped were more likely to have colon in circuit (p=0.003) with a significantly longer length of colon (p=0.002). Eleven of fourteen patients who had surgery which did not stop HPN were able to reduce the volume of feed or the number of nights of feed by one year after operation.

Table 5 shows all abdominal operations which were performed while patients were on HPS. One hundred and six operations were performed in 81 patients, median 1 operation/patient (range 1-5) Fifty-six patients had only one operation. Not all operations had the sole aim of stopping HPS. Some patients wished treatment of their enterocutaneous fistulae or obstruction because of symptoms and stopping HPS was less of a priority. Seven operations were emergencies for intra-abdominal complications and some were not directly related to intestinal failure. Eleven cholecystectomies were performed as part of other operations, with only one cholecystectomy performed with no other procedure.

No deaths occurred within 30 days of surgery. One patient who had small bowel transplant was found to have lung cancer immediately before discharge following transplant, despite extensive negative investigation pre-operatively. She was treated but did not survive. Another patient died at 85 days after a liver transplant for liver disease which pre-dated his intestinal failure.

Eighteen Clavien-Dindo grade 3 or 4 complications [9] occurred within 30 days of 104 operations (not including bowel transplants). The details are shown in Table 5.

Five patients who did not stop HPS after reconstructive surgery sustained post-operative complications which in four patients likely contributed to the failure to stop HPS. Three patients had post-operative small bowel fistula, two of which were recurrent. All had low output fistulas. One patient was found to have unexpected active Crohn’s disease in his resection specimen and had ongoing obstructive symptoms post-operatively. The fifth patient had re-anastomosis of a very short length of small bowel to colon but developed colonic ischaemia post-operatively and required take-down of the anastomosis and colonic resection.

Forty one patients stopped HPS at discharge from their major procedure. Six others stopped immediately after subsequent closure of a relatively proximal defunctioning jejunostomy. Three patients were slowly weaned from HPS after closure of a defunctioning jejunostomy. Six patients were weaned slowly after their major procedure. Two patients had a delay to stopping HPS because of complications of the major procedure. The median time to weaning from HPS in patients who did not stop on discharge was five months (range 1-68). One patient who had re-anastomosis of 75cm small bowel to transverse colon after trauma initially stopped HPS at 14 months postop but restarted some intravenous fluids five months later because of recurrent lethargy and electrolyte disturbance. Eventually he was referred to the UK National centre for Autologous GastroIntestinal Reconstruction in Salford for consideration of Serial Transverse Enteric Plication (STEP). Reassessment there enabled him to stop his intravenous fluids at 68 months following his re-anastomosis surgery. He did not undergo STEP.

Although the number of HPS patients increased over the years, there was not a significant increase in the percentage of patients who had surgery which led to stopping HPS.

Figure 2 compares survival of nonpalliative patients who remained dependent on HPS with survival of those who stopped HPS after surgery. There is a statistically significant survival advantage ($p<0.001$).

DISCUSSION

We have not found a previous study looking specifically at the role of surgery in an entire cohort of HPS patients. Twenty eight percent of our patients were able to stop HPS after surgery. We have also demonstrated significant survival benefits for patients who stopped HPS after surgery.

Our HPS dependence of 56% at 5 years compares with 84% in a study from St Mark's[7] and 63% in a study from Salford [8], the two UK National Intestinal Failure centres. This probably reflects different case mix. The number of patients weaned due to surgery was significantly more than those who weaned because of more aggressive medical treatment of their underlying disease or bowel adaptation.

Although the current study is smaller than the Salford outcome study which included 545 patients over 33 years (8), no details about the 77 patients who stopped HPS in Salford after surgery are given, other than that reconstructive surgery was performed in 84 patients. After operation, 80% of our patients weaned from HPS in comparison to 92% in the Salford study. The indications for operation

are not given in the Salford study. Some of our patients had surgery partly because of unacceptable symptoms from fistulae or obstruction with weaning from HPS a secondary aim. Although not all of our patients were able to stop HPS after surgery, eleven of the fourteen who did not stop HPS were able to reduce the volume of feed or number of nights of feed over the next year. Relief of obstruction or control of fistulas was another worthwhile indication for surgery, with the aim of improving quality of life.

Other studies have reported surgery in specific patient groups. Adaba [9] reported that over five years following re-anastomosis of bowel after mesenteric infarction, 44 of 57 operated patients stopped HPS. A number of publications look at outcome after enterocutaneous fistula surgery [10,11,12,13,14] but these were not limited to patients who required HPS.

Not surprisingly bowel length was the most important factor in achieving nutritional autonomy. In 1992 Nightingale [15] emphasised the importance of both small bowel length and preservation of colon in avoiding the need for parenteral supplements and Jeppesen [16] has demonstrated that in the context of short gut, colon is able to absorb medium chain fatty acids which contribute to nutritional balance. Patients likely to benefit from reconstructive surgery should be identifiable once the recruitable length of bowel is known.

Excellent communication between the members of the multidisciplinary team is necessary in managing intestinal failure patients and this demonstration that surgery is the most important means of weaning patients from HPS suggests that regular active involvement of surgeons as part of the nutrition team is essential. The European Society for Coloproctology has produced guidelines for surgery in IF patients [17].

We did not find any disease or indication for HPS predicted success in reconstructive surgery. The principal indication for consideration of reconstructive surgery is the available of defunctioned bowel which could be put back into circuit. Although one might hope that patients whose intestinal failure was due to a post-operative complication might be more likely to wean from HPS after further surgery, this was not the case. The St Mark's group have already shown that re-anastomosis following resection for ischaemia can be successful [9]. In a previous report on intestinal failure and radiation enteritis, Kalaiselvan [18] reported that more than half of the patients presented with obstruction but

all had operation at the referring hospital prior to referral to the IF unit. Only one of thirteen patients with radiation enteritis discharged on HPS stopped HPS because of intestinal reconstruction. This contrasts with five of our eighteen radiation enteritis patients stopping HPS post-operatively. It may be that patients with IF due to radiation enteritis should be referred for nutritional support prior to any operation to try to improve the chances of success. Twelve patients with motility disorders were not considered appropriate for surgery in our group and two patients with chronic intestinal pseudo-obstruction who required emergency surgery for volvulus were not considered part of the group in whom we thought reconstruction might succeed (groups B+C). Surgery should be avoided in patients with motility disorder except for volvulus or for carefully considered massive enterectomy because of distension.

This series supports the importance of delaying reconstructive surgery until the patient is as fit as possible and the abdomen has become softer, with a median time on HPS of 238 days. A meta-analysis in 2013 emphasised the importance of delayed surgery for intestinal fistulae, having found lower recurrence rates in studies where the time interval to surgery was longer [12]. It was noted that the study with the highest mortality had the shortest interval to definitive surgery [13]. Runstrom et al [10] noted that a low serum albumin, high C reactive protein and high white cell count were associated with death following operation for fistula, indicating that freedom from sepsis and recovery of the patient's general health are important parts of preparation. It is more difficult to identify objectively whether the peritoneal cavity has reformed. If a fistula or stoma begins to prolapse, this indicates that there should not be severe intra-abdominal adhesions at least around the area of the stoma, but expert opinion recommends that the abdomen should also feel softer before surgery for intestinal failure [17]. Detailed assessment of general fitness, underlying disease and the anatomy of gut, especially distally, is wise.

Reanastomosis of the bowel was the most common operation leading to stopping HPS. It is obvious that maximising the length of bowel available for absorption is important in rehabilitation of intestinal failure but the importance of the role of the colon in salt and water absorption has again been demonstrated[7, 14].

Patients who have enterocutaneous fistulae generally want surgery because of symptoms, whether in association with intestinal failure or not. In our patients, fistula surgery was the second most procedure leading to cessation of HPS. However nearly one third of patients who had fistula surgery did not stop HPS. Most of these patients had opted for surgery to relieve symptoms in the knowledge that because of their bowel length, they were unlikely to stop HPS. Although 3 of the 29 had recurrent fistulation, all three had much lower output than previously. This rate of fistula recurrence is in keeping with other reports [10,11,12].

Seven of the fourteen patients who had surgery for bowel obstruction causing IF managed to stop HPS in the post-op period. Five of the patients who stopped HPS had radiation enteritis and two had Crohn's disease. All presented extremely malnourished and HPS was used to improve their condition prior to operation. Those who failed to stop HPS often had a short length of remaining bowel and two patients who did not stop HPS had volvulus in association with Chronic Intestinal Pseudo-obstruction.

This series does not include the more esoteric non-transplant procedures to slow gut motility or "lengthen" the bowel. Segmental reversal of a length of small bowel has been practised mainly in France [19,]. It does not require dilated bowel. Serial Transverse Enteric Plication (STEP) [20] was considered in one of our patients but found not to be necessary when he was assessed at the National Centre for Autologous GastroIntestinal Reconstruction in Salford. STEP has been used mainly in children and despite assiduous review of adult HPS patients from major centres in the UK, few patients have been found to be appropriate for this procedure.

Only two of our patients had small bowel transplants, although six others have been referred for assessment over the years. Their surgical details are not further considered here. Both stopped HPS after their transplants. With the improving outcome of bowel transplantation [21] it seems likely that more patients will be considered in the future. The UK National Assessment for Small Intestinal Transplant forum meets four times annually to discuss all patients in whom transplant is being considered. A more formal local review mechanism to ensure that all appropriate patients are considered for transplant would be appropriate.

Many intestinal failure patients have severe intra-abdominal pathology and have had multiple laparotomies in the past. Surgery to attempt to wean them from HPS can be difficult. The counter

argument to the complications of surgery is the complication rate of long term intravenous support. This includes catheter related blood stream infection, liver dysfunction and loss of venous access. The burden of ongoing complex medical care for HPS includes not only the inconvenience of the treatment itself but of hospital stay because of complications. Discussion of the risks must be undertaken and some patients do not wish to undergo further operation. Fortunately it seems that immediate mortality from reconstructive surgery is not excessive, although a caveat must be that the numbers are relatively small and the patients carefully selected in a unit with a specialist interest. Our patients suffered eighteen Clavien Dindo Classification grade 3-4 complications [6] within 30 days of 104 operations. There were at least as many complications after laparotomy and re-anastomosis of bowel as after surgery for fistula and obstruction, which might be considered more complex. Although the principle of laparotomy and reanastomosis of the bowel is straightforward, adhesions and the underlying pathology may make surgery difficult. Complications may contribute to failure to wean from HPS. A low output enterocutaneous fistula or ongoing obstructive symptoms will influence the patient's ability to achieve the hyperphagia needed to stop HPS. It is important to note that this is not always immediate. A proximal stoma to defunction high risk or multiple anastomoses may necessitate ongoing parenteral support until this is closed. If the overall bowel length is fairly short, it seems wise to maintain a reduced level of HPS until it is clear that oral or enteral intake is adequate.

Perhaps the most striking outcome of this study is the significant difference in survival between those who stopped and did not stop HPS.. We are confident of the accuracy of our data for deaths given the inter-linked Scottish clinical IT systems which update any patient deaths. Although the advantage of stopping HPS might be intuitive, it is difficult to explain for two reasons. We were only able to demonstrate minor differences between the group who had surgery and those who did not have surgery (slightly younger and less likely to have other illness). In addition, the main causes of death in this study were the disease underlying the need for HPS and unrelated causes. This is not a randomised study. It may be that those having surgery are a selected group despite our inability to demonstrate this statistically. Those for whom reconstructive surgery is not an option probably do have more severe underlying disease. Moreover although the complications of HPS have reduced in the past 50 years, this remains a non-physiological means of nutrition, in particular bypassing the hepatic portal system. In recent years, the value of the gut microbiome to general health has been emphasised [22] and so the loss of gut and its associated bacteria may contribute to ill health. Complications of HPS not severe enough to cause mortality may also contribute. Patients who require

renal dialysis have a higher incidence of co-morbidity than the general population and it seems reasonable to assume that intestinal failure requiring a non-physiological intervention may also be associated with co-morbidity. This area would merit further study.

This report is limited by the retrospective analysis of a database designed for the management and audit of a Home Parenteral Support service. The data is observational although it was collected prospectively. It is inevitable that assumptions and arbitrary cut-off points have been used, for example, the definition of intestinal failure due to post-operative complications included operations during the index admission rather than considering earlier operations. At the time of analysing this data, approval for the use of teduglutide, a glucagon-like peptide which promotes mucosal growth, was not available in Scotland. This drug has since been approved by the Scottish Medicines consortium and may contribute to weaning from HPS in the future [23].

We did not consider abdominal wall reconstruction in any detail. The data collected prospectively did not include detail about this aspect of surgery. In general, a simple approach was favoured. The abdomen was closed with the aid of component separation and absorbable mesh if needed but only one patient had plastic surgical involvement at the end of the laparotomy to perform a musculocutaneous flap to enable closure. Non-absorbable mesh was not used to repair abdominal wall defects at the same operation as bowel anastomosis. Others have reported high rates of mesh infection and bowel fistulation in association with non-absorbable mesh[14] and many of our referrals had previous non-absorbable mesh insertion contributing to their intestinal failure complications.

This is an observational study. It is difficult to be entirely sure that no patient who had surgery would have stopped HPS with conservative treatment. There was considerable delay before operation given the passage of time during the initial admission when starting HPS followed by purposeful delay before reconstructive surgery. Spontaneous resolution of enterocutaneous fistula and obstruction or bowel adaptation should have taken place over this time.

In conclusion, home parenteral support may offer a bridge to reconstructive surgery for more than one quarter of patients with intestinal failure. Any patient who has bowel which can be brought into use should be considered for operation once they are deemed fit enough. Careful consideration of the complications of both surgery and long term HPS is necessary. It appears that patients who can stop HPS have a survival advantage.

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Table 1 – patient demographics and clinical characteristics at start of HPS

	n	**percentage**
Total number of patients	205	
Sex ratio		
Male	78	38%
Female	127	62%
Age at discharge median (range)	56 (15-85)	
Other Illness	80	39%
Underlying disease		
Crohn's	40	19%
Ischaemia	47	23%
Malignancy	37	18%
Radiation	18	9%
Motility	14	7%
Other	49	24%
Palliative intent of treatment at discharge		
yes	18	9%
No	187	91%
Small Bowel Length in circuit at discharge median (range)	75cm (0-280)	
Indication for HPS		
Fistula	35	17%
Malabsorption	7	3%
Obstruction	39	19%
Short gut	118	58%
Other	6	3%

Table 2 – outcome at 31 Dec 2018. IFALD = intestinal failure associated liver disease; CRBSI = catheter associated blood stream infection.

Outcome	n	percentage	detail	n
Total number of patients	205			
Stopped after surgery	58	28%	transplant	2
			reconstruction	56
Recovered	12	6%	Med Rx of Crohn's	1
			Bowel adaptation	9
			Fistula closed	2
HPS dependent	66	32%		
Death on HPS	55	27%	HPS alone (2 CRBSI; 3 IFALD)	5
			IFALD + underlying disease	5
			IFALD + severe pancreatitis	1
			Underlying disease	27
			Unrelated cause	17
Transferred out of our care	4	2%		
HPN withdrawn	10	5%	Terminal malignancy	5
			Patient request	2
			Repeated line infections	2
			Not taking feed	1

Table 3 – The division of patients into groups for analysis. Some patients had more than one operation, but have been categorised here based on main gastrointestinal operations. CIPO = Chronic intestinal pseudo-obstruction

Group A		**Group B**		**Group C**	
Patients with no operations on HPS	124	Patients who had surgery which did not stop HPS	14	Patients who stopped HPS after reconstructive surgery	58
Recovered	12				
No unused gut	36				
Patient choice	9				
Motility disorder	12				
Patient unfit	20				
Recent discharge	14				
Palliative	18				
Not clear	1				
		Exclusions from Group B			
		Operations for sepsis only	2		
		Resection for Crohn's complications	2		
		CIPO with volvulus	2		
		Further Surgery which did stop HPS	3		

Table 4 – Demographics and clinical characteristics of patients with regard to surgery after HPS commenced. The two patients who stopped HPS after transplant are not included in this comparison.

	No abdominal surgery on HPS (Group A)	**Surgery which did not stop HPS (Group B)**	**Stopped HPS after surgery (Group C)**	**Group B vs Group C**
Total number of patients	124	14	56	
Male	45 *(36%)*	2 *(14%)*	25 *(45%)*	P=0.07
Female	79 *(64%)*	12 *(86%)*	31 *(55%)*	
Age at discharge median (range)	57 (19-85)	55 (22-71)	51 (15-82)	P=0.7
Small Bowel Length at HPS discharge (97patients) median (range)	80cm (0-280)	40 (10-100)	75cm (10-140)	P=0.97
Other Illness	54 *(44%)*	4 *(29%)*	16 *(29%)*	P=0.74
Underlying disease				
Crohn's	21 *(17%)*	3 *(21%)*	13 *(23%)*	P=0.49
Ischaemia	28 *(23%)*	6 *(43%)*	12 *(21%)*	
Malignancy	27 *(22%)*	1 *(7%)*	6 *(11%)*	
Other	31 *(25%)*	2 *(14%)*	18 *(32%)*	
Radiation	7 *(6%)*	2 *(14%)*	7 *(13%)*	
Motility	10 *(8%)*	0	0	
Indication for HPS				
Fistula	21 *(17%)*	2 *(14%)*	11 *(20%)*	P=0.80
Malabsorption	6 *(5%)*	1 *(7%)*	0	
Obstruction	26 *(21%)*	1 *(7%)*	8 *(14%)*	
Short gut	65 *(52%)*	10 *(71%)*	35 *(63%)*	
Other	4 *(3%)*	0	2 *(3%)*	
HPS followed Post-operative Complications	29 *(23%)*	*2 (14%)*	20 *(36%)*	P=0.22
Colon in circuit				
At discharge	45 *(36%)*	3 *(21%)*	3 *(5%)*	P=0.003
Never	79 *(64%)*	7 *(50%)*	10 *(18%)*	
Later	0	4 *(28%)*	43 *(77%)*	
Final SB length		50 *(15-135) (n=10)*	155 *(45-350) (n=46)*	P=0.00001
Final colon in circuit				
none		7 *(50%)*	9 *(16%)*	P=0.002
<1/2		5 *(36%)*	4 *(7%)*	
>1/2		0	22 *(39%)*	
all		2 *(14%)*	21 *(38%)*	

Table 5 – Summary of all abdominal operations while patients were on HPS. *denotes complications which required re-operation during the same admission.

Operation Type	**Total number**	**Number leading to stopping HPN**	**Complications requiring operative* or radiological intervention**	**Number which did not lead to stopping HPN**	**Complications requiring operative* or radiological intervention**
Laparotomy + re-anastomosis	32	28	Fistula 1 – closed spontaneously Abscess 2 Bile leak 1 R colon ischaemia 1* Leak from site of adhesion division 1* Post-op bleed 1*	4	R colon ischaemia 1*
Fistula surgery	29	20	Abscess 1 – open drainage* Fistula – low output	9	Fistula 2 – both low output
Laparotomy for obstruction	14	7	Abscess 1	7	Fistula 1 Mesh infection 1
Local closure of stoma	15	11 (10 following other operations)	none	4 (3 following other operations)	none
Bowel transplant	2	2	Performed in Cambridge		
Other	14	0		Other stoma surgery 4 Renal Transplant 1 L hemicolectomy for perforated Crohn's 1 SB resection for ischaemia 1 Laparotomy for sepsis 2 Removal of infected mesh 1 Redo ileal conduit 1 Incisional Hernia repair 1 Cholecystectomy only 1 Liver Transplant 1 (for previous liver disease)	Fistula 1 – further surgery later Ongoing abdominal sepsis 2 Died post Liver Tx 1
Total	**106 operations in 81 patients**	**68 operations in 58 patients**	**Fistula 2** **Abscess 4 (3 drained radiologically, 1 open)** **Bile leak 1** **Bowel ischaemia 1** **Post-op bleed 1**	**38 operations in 26 patients**	**Fistula 4** **Ongoing abdominal sepsis 2** **Mesh infection 1** **Bowel ischaemia 1** **Died post liver Tx 1**