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Guidelines on the management of ascites in cirrhosis

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► Additional material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/gutjnl-2020-321790).

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Received 11 May 2020
Revised 27 August 2020
Accepted 4 September 2020

To cite: Aithal GP, Palaniyappan N, China L, *et al*. *Gut* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/gutjnl-2020-321790

ABSTRACT

The British Society of Gastroenterology in collaboration with British Association for the Study of the Liver has prepared this document. The aim of this guideline is to review and summarise the evidence that guides clinical diagnosis and management of ascites in patients with cirrhosis. Substantial advances have been made in this area since the publication of the last guideline in 2007. These guidelines are based on a comprehensive literature search and comprise systematic reviews in the key areas, including the diagnostic tests, diuretic use, therapeutic paracentesis, use of albumin, transjugular intrahepatic portosystemic stent shunt, spontaneous bacterial peritonitis and beta-blockers in patients with ascites. Where recent systematic reviews and meta-analysis are available, these have been updated with additional studies. In addition, the results of prospective and retrospective studies, evidence obtained from expert committee reports and, in some instances, reports from case series have been included. Where possible, judgement has been made on the quality of information used to generate the guidelines and the specific recommendations have been made according to the 'Grading of Recommendations Assessment, Development and Evaluation (GRADE)' system. These guidelines are intended to inform practising clinicians, and it is expected that these guidelines will be revised in 3 years' time.

EXECUTIVE SUMMARY OF RECOMMENDATIONS

1. Diagnostic paracentesis in new- onset ascites
   1.1. A diagnostic paracentesis is recommended in all patients with new-onset ascites. (*Quality of evidence: moderate; Recommendation: strong*)
   1.2. The initial ascitic fluid analysis should include total protein concentration and calculation of the serum ascites albumin gradient (SAAG). (*Quality of evidence: moderate; Recommendation: strong*)
   1.3. Ascites fluid analysis for cytology, amylase, brain natriuretic peptide (BNP) and adenosine deaminase should be considered based on pretest probability of specific diagnosis (*Quality of evidence: moderate; Recommendation: weak*)
2. Spontaneous bacterial peritonitis
   2.1. Diagnostic paracentesis should be carried out without a delay to rule out spontaneous bacterial peritonitis SBP) in all cirrhotic patients with ascites on hospital admission. (*Quality of evidence: moderate; Recommendation: strong*)
   2.2. A diagnostic paracentesis should be performed in patients with GI bleeding, shock, fever or other signs of systemic inflammation, gastrointestinal symptoms, hepatic encephalopathy, and in patients with worsening liver or renal function. (*Quality of evidence: moderate; Recommendation: strong*)
   2.3. Ascitic neutrophil >250/mm^3 count remains the gold standard for the diagnosis of SBP and this can be performed either by manual microscopy or using automated counts, based on flow cytometry for counting and differentiating cells. (*Quality of evidence: moderate; Recommendation: strong*)
   2.4. Ascitic fluid culture with bedside inoculation of blood culture bottles should be performed to guide the choice of antibiotic treatment when SBP is suspected. (*Quality of evidence: moderate; Recommendation: strong*)
   2.5. Immediate empirical antibiotic therapy should be determined with due consideration of context of SBP (community acquired or healthcare associated), severity of infection and local bacterial resistance profile. Cefotaxime has been widely studied, but choice of antibiotic should be guided by local resistance patterns and protocol. (*Quality of evidence: moderate; Recommendation: strong*)
   2.6. A second diagnostic paracentesis at 48 hours from the start of treatment to check the efficacy of antibiotic therapy should be considered in those who have apparently inadequate response or where secondary bacterial peritonitis is suspected. (*Quality of evidence: low; Recommendation: weak*)
   2.7. Patients presenting with gastrointestinal bleeding and underlying ascites due to cirrhosis should receive prophylactic antibiotic treatment (cefotaxime has been widely studied but the antibiotic should be chosen based on local data) to prevent the development of SBP. (*Quality of evidence: strong; Recommendation: strong*)
   2.8. Patients who have recovered from an episode of SBP should be considered for treatment with norfloxacin (400 mg once daily), ciprofloxacin (500 mg once daily, orally) or cotrimoxazole (800 mg sulfamethoxazole and 160 mg trimethoprim daily, orally) to prevent further episode of SBP. (*Quality of evidence: low; Recommendation: weak*)
   2.9. Primary prophylaxis should be offered to patients considered at high risk, as defined by an ascitic protein count <1.5 g/dL. However, it

is important that the potential risks and benefits and existing uncertainties are communicated to patients. (*Quality of evidence: low; Recommendation: weak*)

3. Dietary salt restriction

3.1. Patients with cirrhosis and ascites should have a moderately salt restricted diet with daily salt intake of no more than 5–6.5 g (87–113 mmol sodium). This translates to a no added salt diet with avoidance of precooked meals. (*Quality of evidence: moderate; Recommendation: strong*)

3.2. Patients with cirrhosis and ascites should receive nutritional counselling on the sodium content in the diet. (*Quality of evidence: weak; Recommendation: strong*)

4. Diuretics

4.1. In patients with the first presentation of moderate ascites, spironolactone monotherapy (starting dose 100 mg, increased to 400 mg) is reasonable. In those with recurrent severe ascites, and if faster diuresis is needed (for example, if the patient is hospitalised), combination therapy with spironolactone (starting dose 100 mg, increased to 400 mg) and furosemide (starting dose 40 mg, increased to 160 mg) is recommended. (*Quality of evidence: moderate; Recommendation: strong*)

4.2. All patients initiating diuretics should be monitored for adverse events. Almost half of those with adverse events require diuretic discontinuation or dose reduction. (*Quality of evidence: low; Recommendation: weak*)

4.3. Hypovolaemic hyponatraemia during diuretic therapy should be managed by discontinuation of diuretics and expansion of plasma volume with normal saline. (*Quality of evidence: low; Recommendation: weak*)

4.4. Fluid restriction to 1–1.5 L/day should be reserved for those who are clinically hypervolaemic with severe hyponatraemia (serum sodium <125 mmol/L). (*Quality of evidence: low; Recommendation: weak*)

4.5. Hypertonic sodium chloride (3%) administration should be reserved for those who are severely symptomatic with acute hyponatraemia. Serum sodium should be slowly corrected. (Quality of evidence: low; Recommendation: weak)

4.6. It may be appropriate to consider use of midodrine in refractory ascites on a case by case basis. (*Quality of evidence: low; Recommendation: weak*)

5. Large volume paracentesis (LVP)

5.1. Patients should give informed consent for a therapeutic or diagnostic paracentesis. (*Quality of evidence: low; Recommendation: strong*)

5.2. Ultrasound guidance should be considered when available during LVP to reduce the risk of adverse events (*Quality of evidence: low; Recommendation: weak*)

5.3. Routine measurement of the prothrombin time and platelet count before therapeutic or diagnostic paracentesis and infusion of blood products are not recommended. (*Quality of evidence: moderate ; Recommendation: strong*)

6. Use of human albumin solution (HAS)

6.1. Albumin (as 20% or 25% solution) should be infused after paracentesis of >5 L is completed at a dose of 8 g albumin/L of ascites removed. (*Quality of evidence: high; Recommendation: strong*)

6.2. Albumin (as 20% or 25% solution) can be considered after paracentesis of <5 L at a dose of 8 g albumin/L of ascites removed in patients with ACLF or high risk of post-paracentesis acute kidney injury. (*Quality of evidence: low; Recommendation: weak*)

6.3. In patients with SBP and an increased serum creatinine or a rising serum creatinine, infusion of 1.5 g albumin/kg within 6 hours of diagnosis, followed by 1 g/kg on day 3, is recommended. (*Quality of evidence: low; Recommendation: weak*)

7. Transjugular intrahepatic portosystemic shunt (TIPSS)

7.1. TIPSS should be considered in patients with refractory ascites. (*Quality of evidence: high; Recommendation: strong*)

7.2. Caution is required if considering TIPSS in patients with age >70 years, serum bilirubin >50 µmol/L, platelet count $<75\times10^9$/L, model for end-stage liver disease (MELD) score ≥18, current hepatic encephalopathy, active infection or hepatorenal syndrome. (*Quality of evidence: moderate; Recommendation: strong*)

8. Umbilical hernia

8.1. Suitability and timing of surgical repair of umbilical hernia should be considered in discussion with the patient and multidisciplinary team involving physicians, surgeons and anaesthetists. (*Quality of evidence: low; Recommendation: strong*)

9. Hepatic hydrothorax (HH)

9.1. TIPSS should be considered in patients with HH after discussion with the multidisciplinary team. (*Quality of evidence: low; Recommendation: strong*)

9.2. In patients with HH who are not undergoing a TIPSS and/or a liver transplant evaluation, alternative palliative interventions should be considered. (*Quality of evidence: low; Recommendation: strong*)

10. Non-selective beta-blockers (NSBB) and ascites

10.1. Refractory ascites should not be viewed as a contraindication to NSBB. (*Quality of evidence: moderate; Recommendation: strong*)

10.2. Patients with refractory ascites who are taking NSBB should be monitored closely, and dose reduction or discontinuation may be appropriate in those who develop hypotension or acute/progressive renal dysfunction. (*Quality of evidence: moderate; Recommendation: strong*)

11. Automated low-flow ascites pump

11.1. An automated low-flow ascites pump should be considered only in special circumstances with robust arrangements of clinical governance, audit or research. (*Quality of evidence: low; Recommendation: weak*)

12. Palliative care

12.1. Patients with refractory ascites who are not undergoing evaluation for liver transplant should be offered a palliative care referral. Besides repeated LVP, alternative palliative interventions for refractory ascites should also be considered. (*Quality of evidence: weak; Recommendation: strong*)

13. Research recommendations

13.1. Randomised controlled trials (RCT) with large sample size should evaluate the role of antibiotics in the secondary prophylaxis for SBP in ascites secondary to cirrhosis.

13.2. Large RCTs should assess the role of midodrine in the management of ascites.

13.3. Cost-effectiveness of long-term administration of albumin to patients with decompensated cirrhosis and ascites should be evaluated.

13.4. Role of nutritional interventions in the management of ascites should be evaluated.

13.5. Large RCT of long-term carvedilol versus no carvedilol in patients with refractory ascites without large oesophageal varices should be carried out.

13.6. Role of TIPSS in the management of hepatic hydrothorax should be compared with other therapeutic interventions.

13.7. The cost-effectiveness and the effect of automated low-flow ascites pumps on the quality of life of patients with refractory ascites should be evaluated.
13.8. Effectiveness and safety of long-term abdominal drains should be assessed in RCTs for the palliative care of patients with cirrhosis and refractory ascites.

PATIENT SUMMARY

These guidelines have been produced on behalf of the British Society of Gastroenterology (BSG) in collaboration with the British Association for the Study of the Liver (BASL). These guidelines are aimed at healthcare professionals who look after patients with cirrhosis and ascites.

Ascites is the build-up of fluid in the belly (abdomen). This occurs when the liver gets irreversibly scarred, a condition known as cirrhosis. Ascites is the most common complication of cirrhosis.

All patients with a new onset of ascites should have the fluid tested. This involves inserting a small needle into the abdomen and removing about two tablespoons of ascitic fluid. The fluid is then analysed for protein and white cell count. Protein count can help differentiate whether the cause of ascites is cirrhosis or whether the ascites is due to other causes like heart disease or cancer. The white cell count indicates whether there is an infection in the ascitic fluid. If infection is present, this is treated with a short course of antibiotics. Infection of ascites should be ruled out at every hospital admission as it carries a high risk of death and should therefore be diagnosed and treated promptly. After this initial treatment, patients are given long-term antibiotics to prevent repeat infections.

No salt should be added at the table to food. The total amount of salt in food per day should not be more than the equivalent of one teaspoon. Patients should read labels on prepared foods to confirm their daily salt intake is within the limit of 5 g of salt. The initial treatment for patients with ascites involves taking medication, commonly known as 'water tablets' (diuretics). These drugs are begun at a small dose, which is gradually increased until the ascites is treated. Diuretics can have side effects such dehydration, confusion, abnormal levels of sodium and potassium and kidney damage. Therefore patients should be monitored while taking these tablets.

As the liver disease progresses the ascites may no longer respond to medication. This is known as untreatable or refractory ascites. This requires the patient to come into hospital every few weeks to have a temporary drain inserted into the abdomen and the ascitic fluid drained. If more than 5 L of fluid is removed, patients are also given a protein solution into the vein to prevent dehydration.

In patients with untreatable ascites, alternatives to repeated hospital drainage include placing a small tube (stent) in the liver. This specialised procedure is known as a transjugular intrahepatic portosystemic shunt (TIPSS). The TIPSS procedure is effective in reducing the need for repeated fluid drainage. Because of potential side effects, patients should be selected carefully for this procedure. This is particularly true for patients with more advanced liver disease, where the insertion of a TIPSS can potentially be harmful.

The only curative option for untreatable ascites is liver transplantation. If the patient is not suitable for liver transplantation, medical care then focuses on controlling the ascites symptoms. This is known as palliative care. The most common palliative treatment for untreatable ascites is repeated hospital drainage. Alternative treatments for untreatable ascites, such as long-term abdominal drains, need further research.

INTRODUCTION

Contemporary data from an NHS hospital serving a population of 700 000, found 164 adults with a new diagnosis of ascites over a period of 5 years. Of these, 55% had cirrhosis (alcohol-related liver disease 58, non-alcoholic fatty liver disease 21, chronic viral hepatitis 4, autoimmune liver diseases 3 and cryptogenic cirrhosis 4), 29% had malignancies (gynaecological 12, gastrointestinal 25 and others 11), 6% cardiac failure (CF), 3% end-stage renal disease (ESRD) and 7% other aetiologies.

Development of ascites is an important milestone in the natural history of cirrhosis. About 20% of patients with cirrhosis have ascites at their first presentation, and 20% of those presenting with ascites die in the first year of the diagnosis.[1] The aim of this guideline is to review and summarise the evidence that guides clinical diagnosis and management of ascites in patients with cirrhosis.

Pathogenesis

A detailed description of the pathogenesis of ascites formation is beyond the scope of this article, but two key factors involved in the pathogenesis of ascites formation are portal hypertension and retention of sodium and water. This is summarised in figure 1.

An elevated sinusoidal pressure is essential for the development of ascites, as fluid accumulation does not develop at portal pressure gradient below 8 mm Hg, and rising corrected sinusoidal pressure correlates with decreased 24-hour urinary excretion of sodium.[2 3] Architectural changes associated with advanced fibrosis are clearly the primary mechanism underlying increased intrahepatic resistance to the portal flow in cirrhosis. In addition, phenotypic changes in hepatic stellate cells and liver sinusoidal endothelial cells contribute to the pathophysiology. Activated stellate cells become contractile, and their recruitment around newly formed sinusoidal vessels increases the vascular resistance. Reduction in the production/bioavailability of nitric oxide (NO) in the cirrhotic liver adds further to the rise in vascular tone. Overall, vasoconstriction has been estimated to account for about 25% of the increased resistance within the liver.[4]

Increased portal pressure is sensed by intestinal microvasculature that generates angiogenic factors such as vascular endothelial growth factor,[5] and these stimulate the development of portosystemic collaterals through the opening of pre-existing vessels or new vessel formation. When the portal pressure rises further, induction of endothelial nitric oxide synthase and over production of NO leads to splanchnic arterial vasodilatation. This, in turn, increases portal blood flow, thus exacerbating portal hypertension. Portosystemic collaterals also permit vasodilators such as NO, prostacyclin and endocannabinoids[6] to enter the systemic circulation leading to a state of 'effective hypovolaemia'.[7] This activates sympathetic nervous system stimulating reabsorption of sodium in proximal, distal tubules, loop of Henle and collecting duct as well as the renin–angiotensin–aldosterone system, leading to sodium absorption from distal tubule and collecting duct.[8] Renal sodium retention and eventual free water clearance due to non-osmotic release of arginine–vasopressin and its action on V2 receptor in the collecting duct underlie the fluid retention associated with oedema and ascites in cirrhosis.[8]

More recently, it has been hypothesised that bacterial translocation associated with portal hypertension in cirrhosis and related pathogen-associated, molecular pattern activated innate immune responses lead to systemic inflammation.[9] This is associated with vasodilatation as well as release of proinflammatory cytokines, reactive oxygen and nitrogen species, contributing to organ dysfunction.

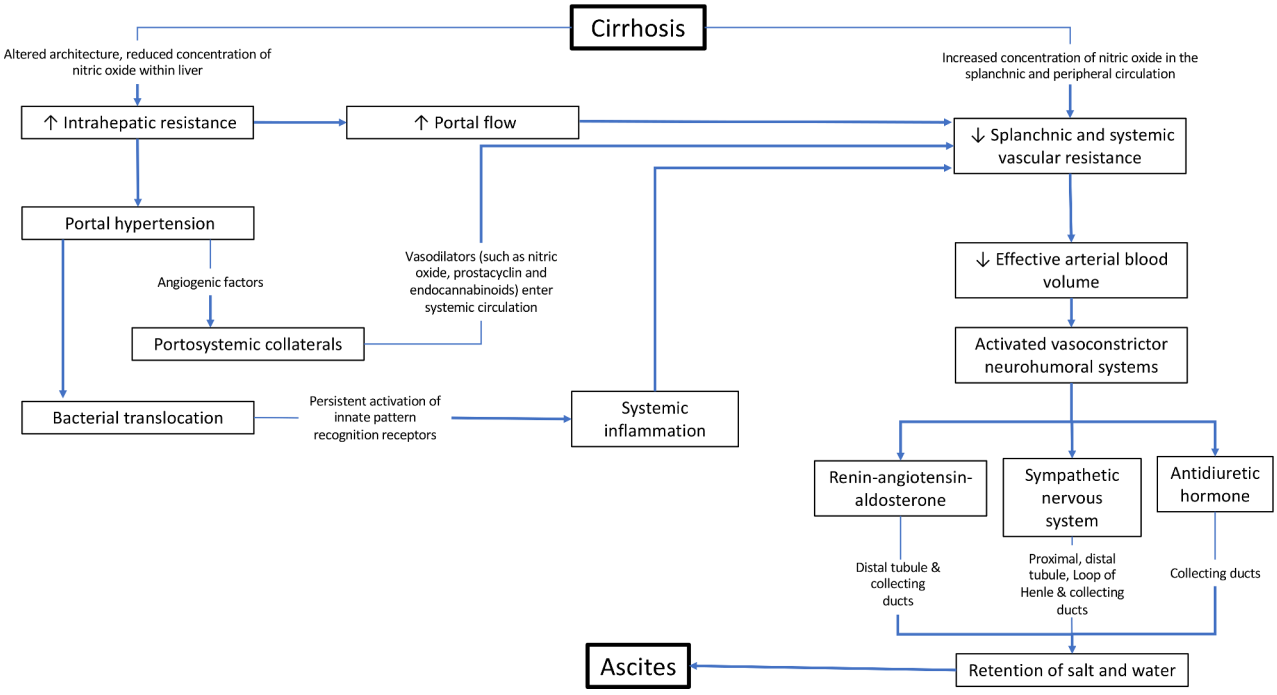

Figure 1 The pathogenesis of ascites in cirrhosis.

Definitions

The terms used in this article have been defined by the International Ascites Club[10]

Uncomplicated ascites

Ascites that is not infected and which is not associated with the development of the hepatorenal syndrome (HRS). Ascites can be graded as mild when ascites is detectable only by ultrasound examination, moderate when it causes moderate symmetrical distension of the abdomen and large when it causes marked abdominal distension.

Refractory ascites

Ascites that cannot be mobilised or the early recurrence of which (ie, after therapeutic paracentesis) cannot be satisfactorily prevented by medical treatment. This includes two different subgroups.

Diuretic-resistant ascites

Ascites that is refractory to dietary sodium restriction and intensive diuretic treatment.

Diuretic-intractable ascites

Ascites that is refractory to treatment owing to the development of diuretic-induced complications that preclude the use of an effective diuretic dosage.

Evaluation of patients with ascites

Clinical evaluation should include history of exposure to risk factors for cirrhosis and physical examination to look for evidence to support chronic liver disease or an alternative diagnosis. Shifting dullness is detectable when about one and a half litres of free fluid accumulate in the abdomen; the physical sign has 83% sensitivity and 56% specificity in detecting ascites.[11 12] However, in the presence of obesity or smaller amount of fluid, imaging such as ultrasound or CT is necessary to confirm the presence of ascites.

DIAGNOSTIC PARACENTESIS IN NEW-ONSET ASCITES

Aspiration of ascitic fluid and its laboratory analysis is an essential step in the management of patients with newly diagnosed ascites. In cirrhosis, hepatic sinusoids are less permeable owing to fibrous tissue deposition, resulting in ascites with low protein content. It is important to estimate total protein level in ascites fluid; a concentration below 1.5 g/dL (or 15 g/L) is a risk factor for the development of spontaneous bacterial peritonitis. In addition, serum ascites albumin gradient (SAAG) should be estimated routinely. A cut-off point of 1.1 g/dL (or 11 g/L) differentiates between causes of ascites with high sensitivity,[13–18] although alternative causes should be considered based on the clinical scenario (table 1).

Hepatic sinusoids are normally permeable in heart failure, which allows for leakage of protein-rich lymph into the abdominal cavity and therefore, total protein concentration in ascitic fluid is high (>2.5 g/dL) in combination with a high SAAG. In such a situation, measurement of brain natriuretic peptide (BNP) in the serum±ascites is useful. Total protein concentrations >2.5 g/dL within the ascites and serum BNP >364 ng/L are suggestive

Table 1 Grouping of aetiology of ascites based on serum albumin ascites gradient (SAAG)

SAAG ≥11 /L	SAAG <11 /L
Portal hypertension	Peritoneal carcinomatosis
Cardiac failure	Peritoneal tuberculosis
*Portal vein thrombosis**	*Pancreatitis**
*Hypothyroidism**	*Bowel perforation**
	*Nephrotic syndrome**

*Limited data[27 283 284]

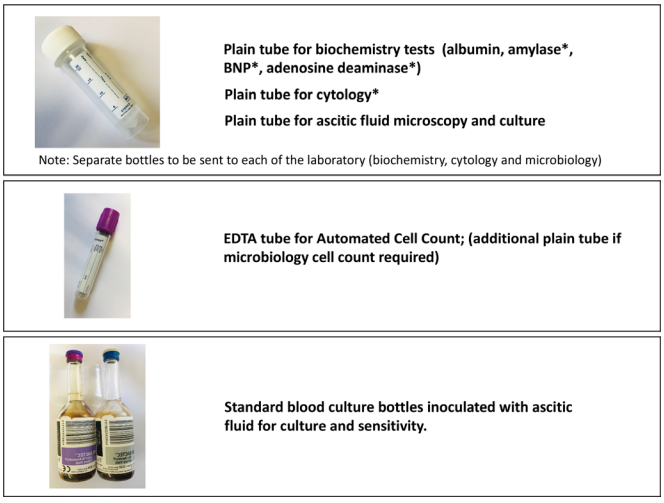

Figure 2 The ascitic fluid samples required from diagnostic paracentesis. *These investigations should be considered based on pretest probability of specific diagnosis. BNP, brain natriuretic peptide.

of underlying or additional cardiac disease, whereas serum protein values <182 ng/L rule out cardiac disease.[19]

In low SAAG states, clinical context and imaging should guide the investigational approach. The yield for positive cytology in the context of malignancy is variable, ranging from 0% to 96.7%, in part determined by the site of the tumour.[20 21] Combining cytology with tumour markers in the ascitic fluid may increase the positive predictive value (PPV), specifically the use of carcinoembryonic antigen (CEA), epithelial cell adhesion molecule (EpCAM), CA 15-3 and CA 19-9.[20] However, CA 125 in the serum or ascites has no role as a discriminator and will commonly be elevated by the presence of ascites from any cause.[22]

Where peritoneal TB is considered plausible, ascites can be sent for acid-fast bacilli smear and culture, although culture positivity occurs in <50% and smear-positive ascites is rare.[23] Adenosine deaminase is more useful to distinguish between peritoneal TB and carcinomatosis, with an area under the receiver operating characteristic curve of 0.98; adenosine deaminase levels of <40 IU/mL are used to exclude TB.[24 25]

Pancreatic ascites is a rare complication of pancreatitis, although more common when a pseudocyst is present. In pancreatic ascites, the amylase level in the ascitic fluid is typically >1000 IU/L or greater than six times the serum amylase, with mean values exceeding 4000 IU/L in a recent cohort of 80 patients.[26] Raised polymorphonuclear leucocytes (PMN) count may also be found in pancreatic ascites.[27]

The ascitic fluid samples required from the diagnostic paracentesis is summarised in figure 2.

Recommendations

- A diagnostic paracentesis is recommended in all patients with new-onset ascites. (*Quality of evidence: moderate; Recommendation: strong*)
- The initial ascitic fluid analysis should include total protein concentration and calculation of SAAG. (*Quality of evidence: moderate; Recommendation: strong*)
- Ascites fluid analysis for cytology, amylase, BNP and adenosine deaminase should be considered based on pretest probability of specific diagnosis (*Quality of evidence: moderate; Recommendation: weak*)

SPONTANEOUS BACTERIAL PERITONITIS (SBP)

Spontaneous bacterial peritonitis is the development of bacterial infection of ascites in the absence of any intra-abdominal surgically treatable source of infection. The prevalence of SBP in outpatients is 1.5–3.5% and approximately 10% in hospitalised patients.[28] A recent European study detected a prevalence of 11.3% among inpatients.[29] When first described, mortality associated with SBP exceeded 90%, but, in-hospital mortality has been reduced to approximately 20% with early diagnosis and prompt treatment.[30] In an observational study, each hour of delay in diagnostic paracentesis after admission was associated with a 3.3% increase of in-hospital mortality after adjusting for model for end-stage liver disease (MELD) score.[31] Long-term survival remains poor; 1-year survival after hospitalisation with SBP in a UK study was found to be 34%.[32] Patients recovering from an episode of SBP should always be considered as potential candidates for liver transplantation if they have not already been assessed.

Diagnosis of SBP

The diagnosis of SBP is confirmed when ascitic neutrophil count is >250 cells/mm^3 in the absence of an intra-abdominal and surgically treatable source of sepsis. A cut-off point of 250 neutrophils/mm^3 has the greatest sensitivity, although a cut-off point of 500 neutrophils/mm^3 has greater specificity.[33] A meta-analysis of primary data from 14 prospective trials has defined the positive and negative likelihood ratios of SBP at different thresholds for total white cell count (WCC) and PMN in ascitic fluid. WCC >1000 cells/µL or PMN ≥500 cells/µL are most accurate and yield positive likelihood ratios of 9.1 (95% CI 5.5 to 15.1) and 10.6 (95% CI 6.1 to 18.3), respectively. Likelihood ratios for WCC >500 cells/µL (5.9; 95% CI 2.3 to 15.5) and PMN >250 cells/µL (6.4; 95% CI 4.6 to 8.8) support routine clinical practice of using lower thresholds, where the greater risk lies with underdiagnosing SBP.[18]

Historically, ascitic neutrophil counts have been performed by manual microscopy, but, this is time and cost intensive. Automated counts, based on flow cytometry for counting and differentiating cells, are now used in most centres. This technique has been shown to have sensitivity and specificity close to 100%,[34 35] allowing a tube containing ethylenediamine tetra-acetate (EDTA; as used for plasma full blood count) to be inoculated with ascitic fluid and processed on a standard blood count analyser. Reagent strips have insufficient sensitivity for reliable use in this context[36] and hence cannot be recommended to replace cell count to diagnose SBP.

Ascitic fluid culture

Ascites culture is essential to help guide antibiotic therapy. Patients with 'culture-negative neutrocytic ascites' (PMN count >250 cells/mm^3) have a similar presentation to those with culture-positive SBP. As both groups of patients have significant morbidity and mortality,[37 38] they should be treated in a similar manner. Some patients have 'bacterascites' in which cultures are positive, but, ascitic neutrophil count is <250 cells/mm^3. In some patients, bacterascites represents a transient and spontaneously reversible colonisation of ascites, in others, particularly those who are symptomatic, it may represent the first step in the development of SBP.[33] Discussion with microbiologists about the organism cultured can help differentiate the above two scenarios, and when a positive culture is obtained a repeat tap should be sent to guide management.

Although the identification of pathogen(s) is essential for the management of infectious diseases, ascites fluid cultures often fail to provide positive results, even when using ascites samples

from patients who develop clinical manifestations of SBP. Bacterial DNA detection and sequencing have been applied to the diagnosis of several infectious diseases, and molecular techniques can detect small amounts of bacterial DNA within a few hours. These promising techniques have yet to be introduced into routine clinical practice.[39]

Fungal peritonitis is a rare, less studied complication and observational data suggest a worse prognosis.[40] In a large multicentre study of 2743 cirrhotic inpatients, of whom 1052 had infections, 12.7% of infected patients had evidence of fungal infections with a case fatality of 30%. The majority of these were urinary, but the highest mortality was seen with fungaemia and peritonitis (case fatality >50%).[41]

Secondary bacterial peritonitis

A small proportion of patients with cirrhosis may develop peritonitis secondary to perforation or inflammation of an intra-abdominal organ, known as secondary bacterial peritonitis. In a small retrospective analysis, secondary peritonitis represented 4.5% of all peritonitis in cirrhotic patients.[42] This should be suspected in those who have localised abdominal symptoms or signs, very high ascitic neutrophil count, the presence of multiple organisms on ascitic culture or in those with inadequate response to treatment.[42] Cross-sectional imaging, such as CT, should be performed with early consideration of surgery in this scenario.

Antibiotic therapy

The most common organisms isolated in patients with SBP include *Escherichia coli*, Gram-positive cocci (mainly streptococcus species) and enterococci. Empirical antibiotic therapy must be initiated immediately after the diagnosis of SBP.[33] In the 1990s, cefotaxime, a third-generation cephalosporin, was extensively investigated in patients with SBP because it was found to cover 95% of organisms and high ascitic fluid concentrations could be achieved.[43 44] The take home message from these studies is that matching an effective antibiotic to the cultured organism is key to successful treatment, rather than any apparent superiority of one drug over another. Since these studies, the landscape of bacterial resistance has significantly changed with an increase in antimicrobial resistant organisms,[45] and therefore recommending a specific single empirical antibiotic is challenging. Thus, it is crucial to separate community-acquired SBP from healthcare-associated SBP (nosocomial – defined as infection >48 hours after hospital admission)[46] and to consider both the severity of infection and the local resistance profile in order to decide the empirical antibiotic treatment of SBP.[47] Over recent years there has been a significant increase in the number of infections caused by multidrug-resistant organisms,[29 48] defined by an acquired non-susceptibility to at least one agent in three or more antimicrobial categories.[49] It is also important to highlight the shift to extensively drug resistant bacteria, defined by non-susceptibility to at least one agent in all but two or fewer antimicrobial categories, or to pan-drug resistance bacteria, defined by non-susceptibility to all agents in all antimicrobial categories.[49]

A second diagnostic tap should be considered at 48 hours from starting treatment, to check the efficacy of antibiotic therapy in patients who have an apparently inadequate response. If ascitic fluid neutrophil count fails to decrease to less than 25% of the pretreatment value, this should raise suspicion of antibiotic resistance or the presence of 'secondary peritonitis'.[33 50] Specialist microbiology links should be developed within each trust to help guide local policy and patient management and, in addition, de-escalation of anti-microbial agents according to susceptibility of positive cultures is recommended.

The evidence for the use of human albumin solution and recommendations for its use in SBP are discussed in a separate section below.

Prophylactic therapy for SBP

Three groups at high risk of developing SBP have been identified: (i) patients with acute gastrointestinal (GI) haemorrhage; (ii) patients with a low ascitic protein concentration and no prior history of SBP (primary prophylaxis) and (iii) patients with a previous episode of SBP (secondary prophylaxis).[51] Although antibiotic prophylaxis to prevent further infection in patients presenting to hospital with upper GI bleeding is established in clinical practice,[52–54] there remains uncertainty over prophylaxis in other circumstances. Additional studies related to this area after the Cochrane review[53] are summarised in online supplemental table 1.

Primary prophylaxis

Primary prophylaxis is a controversial area and broad recommendations are not straightforward. In 2016 the National Institute for Health and Care Excellence (NICE) recommended offering prophylactic oral ciprofloxacin or norfloxacin for people with cirrhosis and ascites and no history of SBP with an ascitic protein of ≤15 g/L (1.5 g/dL), until the ascites has resolved.[55] Six studies were included in their analyses.[56–61] The European Association for the Study of Liver (EASL) recommend primary prophylaxis with norfloxacin (400 mg/day) in patients with Child-Pugh score ≥9 and serum bilirubin ≥3 mg/dL, with either impaired renal function or hyponatraemia and ascitic fluid protein lower than 15 g/L.[47] The American Association for the Study of Liver Diseases (AASLD) also suggest that antibiotics for primary prophylaxis of SBP should be considered for people at high risk of developing this complication, which was defined as an ascitic fluid protein <1.5 g/dL together with impaired renal function or liver failure.[62]

In contrast, in a large placebo-controlled randomised clinical trial, the NORFLOCIR trial, norfloxacin did not reduce 6-month mortality in patients with advanced cirrhosis, with >95% of patients included having no history of prior SBP.[63] In post-hoc analyses, norfloxacin, appeared to increase survival of patients with low ascites fluid protein concentrations. However, other data have failed to replicate an association of incidence of SBP in patients with pre-existing low total ascitic fluid protein concentration in three large cohorts of hospitalised patients with cirrhosis and ascites.[64 65] Furthermore, there are concerns about the potential consequences of long-term oral antibiotic therapy, including resistance, increased risk of *Clostridium difficile* associated diarrhoea, adverse reactions and drug interactions. In 2019 the Medicines and Healthcare products Regulatory Agency (MHRA) issued updated guidance on new restrictions and precautions for use of fluoroquinolone antibiotics following a detailed EU review of very rare reports of disabling and potentially longlasting or irreversible side effects affecting the musculoskeletal and nervous systems. Although SBP prophylaxis was not specifically considered, renal impairment is considered to increase this risk, and therefore healthcare professionals and patients should be vigilant during treatment with fluoroquinolone antibiotics and discontinue treatment at the first sign of tendon pain or inflammation. Finally, norfloxacin is not widely available in the UK.

In view of the uncertainties outlined above, we advocate primary prophylaxis is offered to patients considered at high

risk, as defined by an ascitic protein count <1.5 g/dL. However, it is important that the potential risks and benefits and existing uncertainties are communicated to patients.

It is expected that a large ongoing multicentre UK trial (European Union Drug Regulating Authorities Clinical Trials Database Registration Number: 2019-000581-38) to investigate the efficacy of long-term co-trimoxazole compared with placebo as primary prevention for SBP may deal with these uncertainties.

Secondary prophylaxis

In patients who survive an episode of SBP, the cumulative recurrence rate at 1 year is approximately 70%.[33] Probability of survival at 1 year after an episode of SBP is 30–50% and falls to 25–30% at 2 years.[66 67] There is only one randomised, double-blind, placebo-controlled trial of norfloxacin (400 mg/day) in patients who had a previous episode of SBP[68]; treatment reduced the probability of recurrence of SBP from 68% to 20%. A recent systematic review with meta-analysis concluded that rifaximin may be effective for both primary and secondary SBP prophylaxis compared with systemically absorbed antibiotics and compared with no intervention.[69] However, additional prospective studies are required before a change in clinical practice can be recommended. It has been suggested that proton pump inhibitor use may increase the risk for the development of SBP and indications for long-term use should be carefully assessed.[70 71]

We therefore recommend norfloxacin 400 mg once a day as secondary prophylaxis, although in view of limited availability in the UK, many centres use once daily ciprofloxacin 500 mg once a day as an alternative.

Recommendations

- Diagnostic paracentesis should be carried out without a delay to rule out SBP in all cirrhotic patients with ascites on hospital admission. (*Quality of evidence: moderate; Recommendation: strong*)
- A diagnostic paracentesis should be performed in patients with GI bleeding, shock, fever or other signs of systemic inflammation, gastrointestinal symptoms, hepatic encephalopathy, and in patients with worsening liver or renal function. (*Quality of evidence: moderate; Recommendation: strong*)
- Ascitic neutrophil >250/mm^3 count remains the gold standard for the diagnosis of SBP and this can be performed either by manual microscopy or using automated counts, based on flow cytometry for counting and differentiating cells. (*Quality of evidence: moderate; Recommendation: strong*)
- Ascitic fluid culture with bedside inoculation of blood culture bottles should be performed to guide the choice of antibiotic treatment when SBP is suspected. (*Quality of evidence: moderate, Recommendation: strong*)
- Immediate empirical antibiotic therapy should be determined with due consideration of context of SBP (community acquired or healthcare associated), severity of infection and local bacterial resistance profile. Cefotaxime has been widely studied, but choice of antibiotic should be guided by local resistance patterns and protocol. (*Quality of evidence: moderate; Recommendation: strong*)
- A second diagnostic paracentesis at 48 hours from the start of treatment to check the efficacy of antibiotic therapy should be considered in those who have apparently inadequate response or where secondary bacterial peritonitis is suspected. (*Quality of evidence: low; Recommendation: weak*)
- Patients presenting with gastrointestinal bleeding and underlying ascites due to cirrhosis should receive prophylactic antibiotic treatment (cefotaxime has been widely studied but the antibiotic should be chosen based on local data) to prevent the development of SBP. (*Quality of evidence: strong, Recommendation: strong*)
- Patients who have recovered from an episode of SBP should be considered for treatment with norfloxacin (400 mg once daily), ciprofloxacin (500 mg once daily, orally) or co-trimoxazole (800 mg sulfamethoxazole and 160 mg trimethoprim daily, orally) to prevent further episode of SBP. (*Quality of evidence: low; Recommendation: weak*)
- Primary prophylaxis should be offered to patients considered at high risk, as defined by an ascitic protein count <1.5 g/dL. However, it is important that the potential risks and benefits and existing uncertainties are communicated to patients. (*Quality of evidence: low; Recommendation: weak*)

DIETARY SALT RESTRICTION

There is little evidence to support salt restriction in patients with cirrhosis in absence of ascites. In patients with cirrhosis and ascites, seven RCTs and one cross-sectional survey have examined the role of salt restriction (online supplemental table 2).[72–79] One of the studies has only been published as an abstract.[76] Four of the earlier RCTs[72–75] found no difference in ascites control in those with and without salt restriction. Two recent RCTs found that a salt unrestricted diet (5–6.5 g/day) in contrast to a salt restricted diet (<5 g/day), resulted in ascites disappearance in a larger proportion (45% vs 16%) over a shorter time period and also significantly reduced the need for large volume paracentesis (LVP).[77 78] Additionally, five of the eight above-mentioned studies reported significant adverse events with salt restriction, including hyponatraemia,[72 77] reduced caloric intake,[76 77 79] higher risk of renal impairment (0% vs 14%),[77] hepatic encephalopathy (HE), hepatorenal syndrome (HRS), SBP[78] and mortality.[77 78] In a study by Sorrentino *et al*,[78] 1-year mortality was 45–60% (salt unrestricted diet) versus 82.5% (salt restricted diet).

Thus salt restricted diets (<5 g m of salt, <85 mmol sodium/day) in patients with cirrhosis and ascites do not improve ascites control and, on the contrary, can result in complications. Additionally, such diets are difficult to comply with, especially since the average European ingests about 10 g of salt/day.[80–82] A cross-sectional survey[79] indicated that only about a third of cirrhotic patients were compliant with salt restriction, with an additional 45% incorrectly stating that they were. Based on these data, patients with cirrhosis and ascites should have a moderately salt restricted diet, with daily salt intake of no more than 5–6.5 g (87 mmol–113 mmol sodium). This translates to a no added salt diet with avoidance of precooked meals. An ongoing systematic review is assessing the role of salt restriction in patients with ascites due to cirrhosis.[83]

Recommendations

- Patients with cirrhosis and ascites should have a moderately salt restricted diet with daily salt intake of no more than 5–6.5 g (87 mmol–113 mmol sodium). This translates to a no added salt diet with avoidance of precooked meals. (*Quality of evidence: moderate; Recommendation: strong*)
- Patients with cirrhosis and ascites should receive nutritional counselling on the sodium content in the diet. (*Quality of evidence: weak; Recommendation: strong*)

DIURETICS

Diuretics remain the main stay in management of ascites, though do not modify its natural history, providing only symptomatic benefit.[47] Secondary aldosteronism plays a major role in renal sodium retention in patients with cirrhosis.[84] Spironolactone is a specific pharmacological aldosterone antagonist, acting primarily through competitive binding of receptors at the aldosterone-dependent sodium–potassium exchange site in the distal convoluted renal tubule.[85] Its hydrophilic derivative is potassium canrenoate. They are usually the first-line diuretics used,[84 85] either alone or in combination with a loop diuretic such as furosemide (causing sodium to flood more distal nephron sites).[86] Spironolactone appears to be more effective (response rate of 95%) than furosemide (response rate of 52%) in non-azotemic patients with cirrhosis and ascites.[87 88] Spironolactone has a long elimination half-life, allowing once a day dosing[89–91]; dose changes should occur no more frequently than every 3–4 days.[86]

In those who are intolerant to spironolactone an alternative diuretic is amiloride (acts in the collecting duct). However it is not as effective, an earlier RCT showing response rates of 35% vs 70% in those receiving amiloride versus potassium canrenoate, respectively.[92] Other diuretics which have been used in patients with cirrhosis and ascites include bumetanide[93] and torasemide.[94 95]

Sequential versus combined therapy

Three RCTs assessing the role of sequential therapy (spironolactone followed by furosemide) or combination therapy (spironolactone plus furosemide) have given conflicting results (online supplemental table 3). In the first study,[88] onset of diuresis was faster in the combination group than in the sequential group. The second RCT mostly included those with first presentation of ascites and found no difference in sequential versus combined therapy for the rapidity of ascites mobilisation and incidence of complications. However, a need for dose reductions was significantly higher in the combination group (68% vs 34%).[96] The third RCT included almost two-thirds of patients with prior ascites.[97] It reported shorter mean time for ascites resolution, lower risk of adverse events (especially hyperkalaemia), lower treatment failures (24% vs 44%), with ascites resolving in a higher percentage without need for diuretic dose change (76% vs 56%) in the combination versus sequential group, respectively.[97]

These conflicting results are explained by the heterogeneous patient population as studies by Angeli *et al*[97] and Fogel *et al*[88] included those with more advanced disease, explaining the lower response to spironolactone monotherapy. Others have also reported the likelihood of response to spironolactone monotherapy (vs no response) if a first occurrence (56% vs 37%) rather than recurrent (44% vs 63%) or large ascites (16% vs 58%).[98] Since in non-azotemic cirrhotic patients with ascites, the distal tubule reabsorbs almost all the sodium delivered, it is unsurprising that the administration of spironolactone alone results in a good natriuretic response in most.[96 99] Another advantage of spironolactone monotherapy is its modest diuretic effect,[86] as patients with cirrhosis are sensitive to compromises in their intravascular volume.[91]

Therefore, in patients with first presentation of moderate ascites, starting treatment with spironolactone monotherapy (starting dose 100 mg, increased to 400 mg) is reasonable. In those with persistent or severe ascites, and if faster diuresis is needed (for example, if hospitalised), it may be prudent to use combination therapy with spironolactone and furosemide (starting dose 40 mg, increased to 160 mg). Although maximal daily recommended doses of spironolactone and furosemide are 400 mg and 160 mg respectively,[92 97 98 100] these are rarely achieved.[88 96] In the largest study until now, which recruited about 2000 patients with ascites, at the time of discharge, mean diuretic units (one unit being 40 mg furosemide and 100 mg spironolactone) varied from 2.5+0.2 to 2.7+0.3.[101]

Based on evidence from an earlier RCT, it is recommended that diuretic-induced weight loss should not exceed 0.5 kg/day in patients without peripheral oedema, and 1 kg in the presence of peripheral oedema.[47 100] Figure 3 summarises the stepped-up[98] approach to diuretic treatment.

Adverse reactions to diuretics

All patients initiating diuretics should be monitored for adverse events, the prevalence of which ranges from 19%[96] to 33%.[88 97] Almost half with adverse events require diuretic discontinuation or dose reduction.[88] In hospitalised patients treated with diuretics, hepatic encephalopathy is seen in up to 25%[102] and renal impairment in 14–20%,[97 102] especially in the absence of peripheral oedema.[100] Renal impairment is usually of moderate severity and is reversible on discontinuing diuretics.[10] Hyponatraemia occurs in 8–30% and is related to impaired ability of the kidneys to excrete free water.[10 97] Hypokalaemia is also a frequent side effect of loop diuretics.[10] Similarly hyperkalaemia can occur in up to 11%.[97]

Gynaecomastia is commonly seen with spironolactone, especially with higher doses.[86] It occurs less frequently with potassium canrenoate (53% vs 100%).[103] Eplerenone can also relieve the gynaecomastia.[104 105]

A causal relation is found between cirrhosis and muscle cramps, especially in advanced cirrhosis, with prevalence varying between 26% and 72%,.[106–108] The cirrhosis-induced arterial underfilling probably plays a role in the pathogenesis of cramps.[107] Diuretics accentuate this reduction in effective plasma volume, thereby increasing the prevalence of cramps.[107] An earlier systematic review (including only three RCTs) assessed various interventions for muscle cramps, including zinc, 1-α-hydroxyvitamin D, vitamin E, branched chain amino acids, taurine, intravenous albumin and quinidine. Improvements occurred with most interventions with the exception of vitamin E.[109] Recent RCTs have reported beneficial effects with methocarbamol,[110] taurine[111] and baclofen.[112]

Monitoring of diuretics

The aim of diuretic therapy is to ensure that urinary sodium excretion exceeds 78 mmol/day (88 mmol intake per day – 10 mmol non-urinary excretion per day).[62 113] A random spot urine sodium:potassium ratio between 1.8 and 2.5 has a sensitivity of 87.5%, specificity of 56–87.5% and accuracy of 70–85% in predicting a 24-hour urinary sodium excretion of 78 mmol/day.[114 115]

Hyponatraemia

Recent guidelines define hyponatraemia as a serum sodium <135 mmol/L, with 130–135 mmol/L, 125–129 mmol/L and <125 mmol/L, constituting mild, moderate and severe hyponatraemia, respectively.[47 116] A prospective population survey among patients with cirrhosis found serum sodium <130 mmol/L in 21.6%.[117] Hyponatraemia has been associated with higher prevalence of refractory ascites, hepatic encephalopathy, SBP, HRS and mortality.[117–119] Acknowledging this, the Model for End Stage Liver Disease (MELD) score now incorporates serum sodium (MELD-Na).[120] Those with cirrhosis and chronic hyponatraemia are often asymptomatic and seldom need treatment.[62]

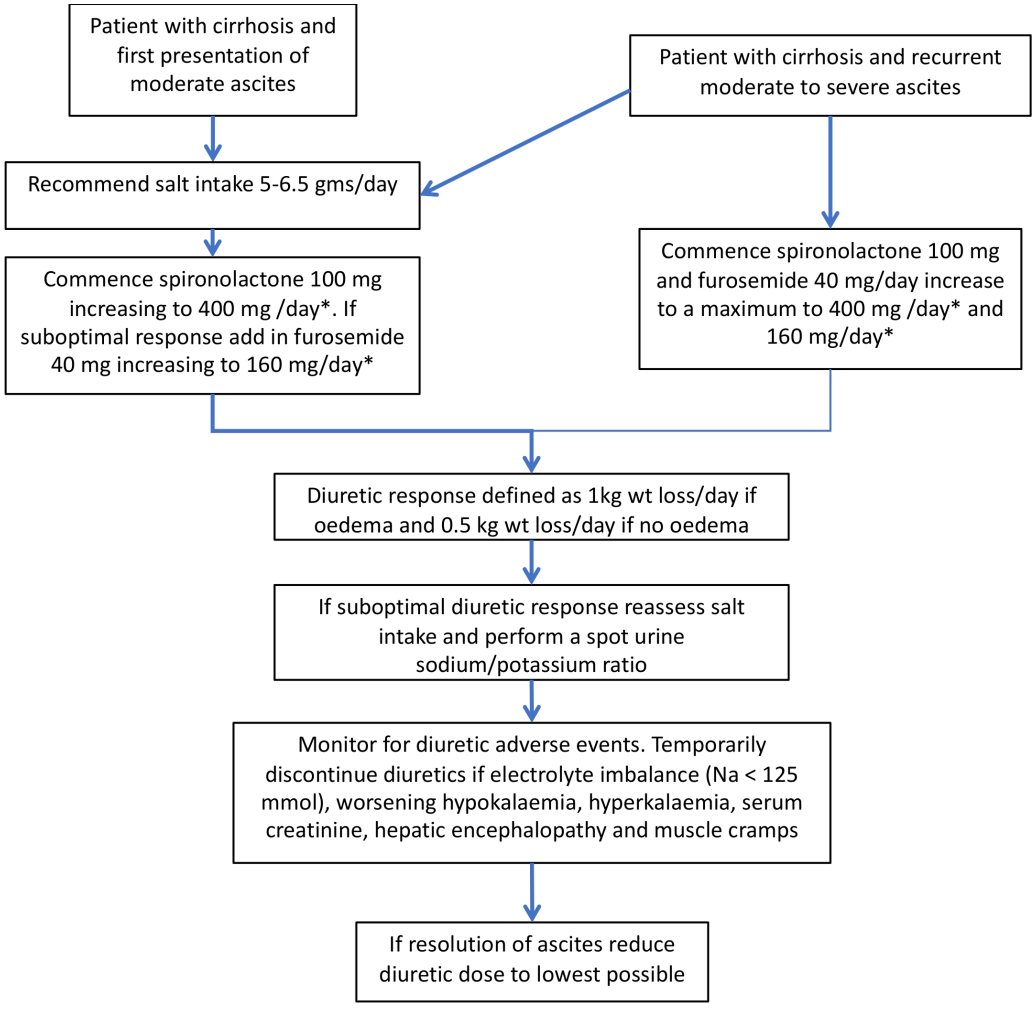

Figure 3 Approach to the use of diuretics in the management of ascites in patients with cirrhosis.

Both hypovolaemic and hypervolaemic hyponatraemia is observed in cirrhosis.[47] Hypovolaemic hyponatraemia results from overzealous diuretic therapy, being characterised by a prolonged negative sodium balance with marked loss of extracellular fluid. Its management requires expansion of plasma volume with normal saline and cessation of diuretics.[47] Most hepatologists would discontinue diuretics if serum sodium is <125 mmol/L.

A number of studies (which include four RCTs and a retrospective cohort study) have assessed role of intravenous (IV) human albumin solution (HAS) in patients with hyponatraemia (online supplemental table 4).[121–126] These studies did not strictly stratify patients as having hypovolaemic hyponatraemia and mostly included those with Child C cirrhosis and refractory ascites undergoing LVP. There were differences in baseline serum sodium levels, use of diuretics, and degree of salt and fluid restriction. Therefore not unsurprisingly results have been conflicting. An earlier meta-analysis that included three of the above RCTs[123–125] reported that use of IV HAS versus no IV HAS reduced occurrence of hyponatraemia (3.9% vs 16.5%) but did not affect mortality.[127] A later meta-analysis (IV HAS vs no IV HAS) which included only two RCTs[123 124] found no beneficial effects on hyponatraemia or mortality.[128] In the retrospective cohort study among hospitalised patients with hyponatraemia (only 42% requiring inpatient LVP), those receiving IV HAS were more likely to have resolution of hyponatraemia than those who did not (85.41% vs 44.78%).[126] Hyponatraemia resolution was an independent predictor of 30-day survival, even after adjustment for admission sodium and glomerular filtration rate. At present, however, there is insufficient evidence to routinely recommend IV HAS outside of a LVP setting in patients with cirrhosis and ascites and hypovolaemic hyponatraemia.

Hypervolaemic hyponatraemia is more common in cirrhosis, occurring owing to non-osmotic hypersecretion of vasopressin and enhanced proximal nephron sodium reabsorption with impaired free water clearance, both being caused by effective hypovolaemia.[47 129] Impaired free water clearance is observed in about 60% of patients with cirrhosis.[130]

Hypervolaemic hyponatraemia requires a negative water balance.[47] Many hepatologists do recommend fluid restriction of between 1 and 1.5 L/day in presence of severe hyponatraemia (serum sodium <125 mmol/L). However, there are few data to support the level of serum sodium at which to initiate fluid restriction and how much fluid to restrict. It is sodium restriction and not fluid restriction that results in weight loss as fluid passively follows the sodium.[62 113 131] Although fluid restriction may be helpful in preventing further decrease in serum sodium, it only rarely improves it. This is because on a practical level, fluid restriction to <1 L /day is not tolerated.[129] Water restriction should be reserved for those who are clinically hypervolaemic

with severe hyponatraemia (serum sodium <125 mmol/L) with normal serum creatinine and not currently receiving diuretics. These recommendations are based on our consensus and consistent with our earlier guidelines.[132] It is also our consensus that fluid restriction is unnecessary in absence of hyponatraemia.

Hypertonic sodium chloride (3%) administration may improve hyponatraemia at the cost of worsening fluid overload. It is best reserved for those with severely symptomatic acute hyponatraemia, especially if a transplant is imminent.[47] To prevent rapid increase in serum sodium and the risk of developing central pontine myelinolysis,[133] guidelines recommend a serum sodium increase of up to 5 mmol/L in the first hour with a limit of 8–10 mmol/L every 24 hours thereafter until the serum sodium concentration reaches 130 mmol/L.[47 116 134 135]

Vaptans

Vaptans are vasopressin antagonists that competitively bind and block the V2-receptors of arginine vasopressin in the renal collecting ducts and induce a highly hypotonic diuresis without affecting the excretion of electrolytes.[136] In three RCTs involving 1200 patients, satavaptan was no more effective than placebo in controlling ascites and need for LVPs, though it improved serum sodium concentration in those with hyponatraemia.[137] Two of the studies were terminated owing to an increase in serum bilirubin, higher mortality (31% vs 22%), mostly due to increased cirrhosis complications and other adverse events.[137] Two meta-analyses[138 139] on vaptans in cirrhosis reported improved serum sodium levels and ascites mobilisation, but without a beneficial effect on cirrhosis-related complications or mortality (RR=1.06, 95% CI 0.90 to 1.26). Current evidence does not support routine use of vaptans in cirrhosis.

Midodrine

Portal hypertension and splanchnic vasodilatation are major contributors to the development of ascites.[7] In fact, mean arterial pressure and plasma norepinephrine are two of the best predictors of prognosis in ascites.[140] Therefore, vasopressors such as midodrine, an α-adrenergic agonist, have been used in non-azotemic patients with ascites, resulting in significant increase in mean arterial pressure and urine sodium excretion and significant decreases in plasma renin and aldosterone.[141]

A small RCT in patients with refractory ascites (midodrine 7.5 mg three times a day vs standard medical therapy) showed that at 3 months 94% versus 50% had a complete/partial ascites control, with a trend for a survival benefit in the midodrine group.[142] In another small RCT (midodrine vs placebo), significant reduction in body weight and abdominal girth was observed after 2 weeks of midodrine therapy.[143] Though larger RCTs are needed to confirm these findings, it may be appropriate to consider use of midodrine in refractory ascites on a case-by-case basis.

Recommendations

- In patients with the first presentation of moderate ascites spironolactone monotherapy (starting dose 100 mg, increased to 400 mg) is reasonable. In those with recurrent severe ascites, and if faster diuresis is needed (for example, if the patient is hospitalised), combination therapy with spironolactone (starting dose 100 mg, increased to 400 mg) and furosemide (starting dose 40 mg, increased to 160 mg) is recommended. (*Quality of evidence: moderate; Recommendation: strong*)
- All patients initiating diuretics should be monitored for adverse events. Almost half of those with adverse events require diuretic discontinuation or dose reduction. (*Quality of evidence: low; Recommendation: weak*)
- Hypovolaemic hyponatraemia during diuretic therapy should be managed by discontinuation of diuretics and expansion of plasma volume with normal saline. (*Quality of evidence: low; Recommendation: weak*)
- Fluid restriction to 1–1.5 L/day should be reserved for those who are clinically hypervolaemic with severe hyponatraemia (serum sodium <125 mmol/day). (*Quality of evidence: low; Recommendation: weak*)
- Hypertonic sodium chloride (3%) administration should be reserved for those who are severely symptomatic with acute hyponatraemia. Serum sodium should be slowly corrected. (*Quality of evidence: low; Recommendation: weak*)
- It may be appropriate to consider use of midodrine in refractory ascites on a case-by-case basis. (*Quality of evidence: low; Recommendation: weak*)

LARGE VOLUME (THERAPEUTIC) PARACENTESIS

Large volume paracentesis (LVP) is the standard of care for managing large volume ascites both in conjunction with diuresis to relieve symptoms of a tense abdomen, as well as in the management of refractory ascites, when diuretics become ineffective or the side effects preclude their continued use. Development of refractory ascites is of prognostic significance,[144] therefore, at its onset, suitability of liver transplantation should be considered and assessed as a priority.

Performance standards

An efficient LVP service can be provided safely in a day case or outpatient setting and non-physician healthcare providers such as GI endoscopy assistants[145] and specialist nurses[146] can be trained to perform therapeutic paracentesis and lead the service effectively. Exemplar training programmes indicate that 10 supervised procedures would be optimal for training to achieve competence in performing therapeutic paracentesis; mean duration of LVP was 97±24 min, and the mean volume of ascitic fluid removed was 8.7±2.8 L.[145]

Patients should provide informed consent before the procedure. In 52 patients (15% obese) with ascites due to cirrhosis, ultrasound demonstrated that the left lower quadrant abdominal wall was thinner and depth of ascites greater, therefore, a suitable site for drain insertion.[147] To minimise the risk of injury to the inferior epigastric artery (and avoid the liver and spleen) during paracentesis, point of puncture should be at least 8 cm from the midline and 5 cm above the symphysis[148–150] (figure 4). All ascitic fluid should be drained to dryness in a single session as rapidly as possible over 1–4 hours assisted by gentle mobilisation of the cannula or turning the patient onto their side, if necessary. After the paracentesis, the patient should lie on the opposite side for 2 hours if there is leakage of any remaining ascitic fluid, and/or a suture (ideally purse-string) inserted around the site of drainage. These steps help to minimise the risk of ascitic fluid leakage.

Adverse events

A systematic review of adverse events that can result from a paracentesis reported an overall rate of significant bleeding ranging from 0% to 2.7%, ascitic fluid leak in 0% to 2.35%, perforation in 0.83%, residual catheter tip fragment in 0.41% and death in 0% to 17% among studies that were heterogeneous.[18] In a retrospective study published in abstract form, of consecutive 3116 ultrasound guided LVPs, the mean international normalised ratio (INR) was 2.1 (range 1.0–7.0) and MELD score 24 (range

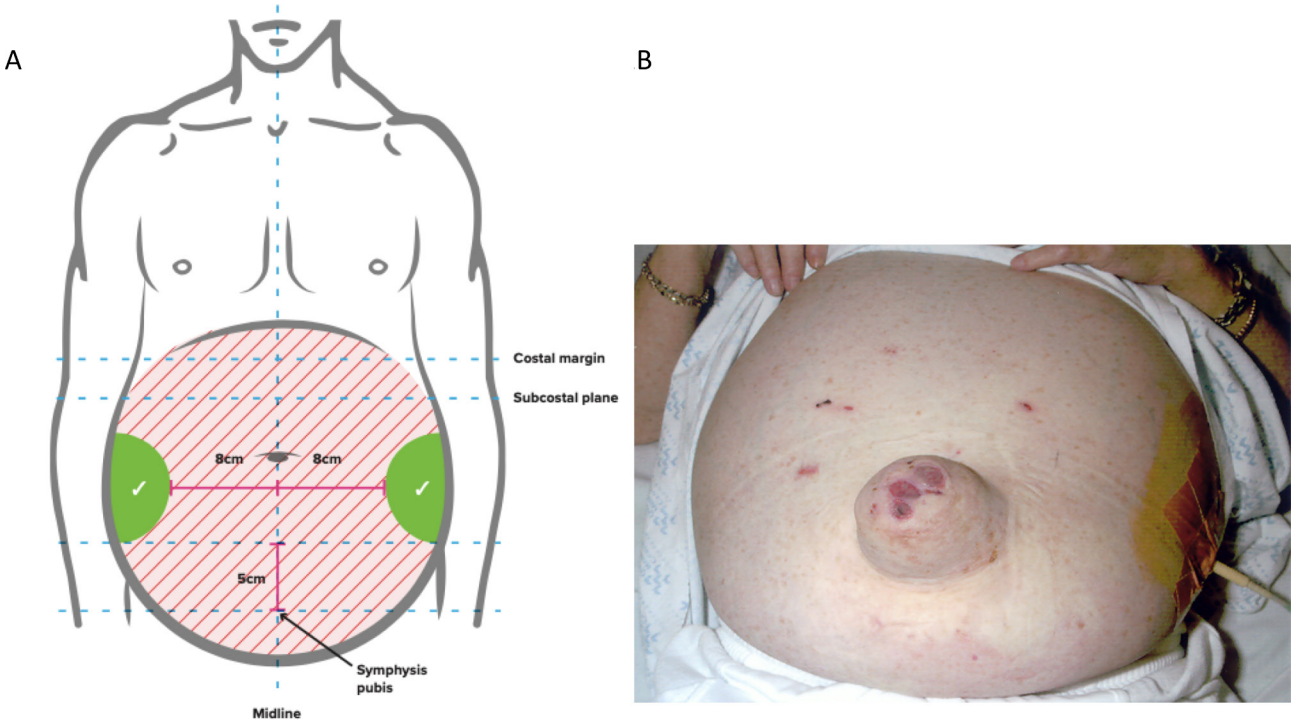

Figure 4 Anatomical landmarks for the safe performance of paracentesis [A] and performance of ascites drainage in patients with large ascites [B].

6–40) for inpatients, and 1.5 (range 1-5–5) and 16 (range 5–40) for outpatients, respectively. With no patients receiving fresh frozen plasma (FFP) before the procedure, a total of six patients (0.19%) had post-LVP bleeding requiring blood transfusion (one inpatient, five outpatients) and one required angiography with embolisation of a bleeding abdominal wall vessel. No patient died.[151] In another study where GI endoscopy assistants performed 1100 large volume paracenteses, with a preprocedure mean INR of 1.7 (range 0.9–8.7) and the mean platelet count was 50.4×10^9/L (range, 19–341×10^9/L), there were no significant procedure-related complications.[145]

Risk factors for haemorrhagic complications after paracentesis in three studies (which included patients with acute on chronic liver failure) were high MELD and Child-Pugh scores and renal impairment.[152–154] In a study by Hung *et al*, acute kidney injury at he time of paracentesis was the only independent predictor of post-paracentesis haemoperitoneum, independent of MELD score, large volume paracentesis, sepsis, platelets, INR and haemoglobin levels.[153] While some patients with bleeding complications after paracentesis have low platelet counts, elevated INR and low fibrinogen levels, this is invariably accompanied with high MELD scores (>25) and/or renal impairment.[152 154]

Ultrasound guidance

Use of ultrasound guidance may reduce the adverse events related to LVP.[155] In a study involving 1297 procedures, 723 (56%) with ultrasound guidance and 574 (44%) without where the indications for paracentesis were similar between the two groups, the incidence of adverse events was lower in the ultrasound-guided procedures.[156] In another retrospective cohort study, 0.8% of 565 patients undergoing paracentesis experienced bleeding complications. After adjustment, ultrasound guidance was associated with lower risk of bleeding complications by 68%.[157]

Recommendations

- Patients should give informed consent for a therapeutic or diagnostic paracentesis. (*Quality of evidence: low; Recommendation: strong*)
- Ultrasound guidance should be considered when available during LVP to reduce the risk of adverse events. (*Quality of evidence: low; Recommendation: weak*)
- Routine measurement of the prothrombin time and platelet count before therapeutic or diagnostic paracentesis and infusion of blood products are not recommended. (*Quality of evidence: moderate and Recommendation: strong*)

USE OF HUMAN ALBUMIN SOLUTION (HAS)

Plasma expansion after paracentesis

One study evaluating haemodynamic and neurohumoral responses in 12 patients after a single, 5 L total paracentesis concluded that it was safe to omit albumin in these patients.[158] However, a subsequent study including 80 patients with acute on chronic liver failure (ACLF) found that albumin significantly reduced complications (renal impairment, hyponatraemia and death) following <5 L paracentesis compared with no administration of fluid.[159] Thus in <5 L paracentesis we recommend that plasma expansion is not necessary, unless there is evidence of ACLF. This recommendation is based on consensus rather than evidence and is consistent with other international guidance.[47]

Plasma volume expansion should always be used for LVP with >5 L of ascites removed. Serial paracenteses with and without albumin replacement have been evaluated in patients with tense ascites.[123 124] There was a higher rate of renal impairment, fall in serum sodium levels, and a marked activation of the renin–angiotensin–aldosterone system in those not treated with albumin. However, the pooled risk ratio from these studies, which are more than 25 years old, showed only a tendency toward benefit of albumin (pooled RR=0.23, 95% CI 0.03 to 1.64) (online supplemental table 5). The consensus is that volume expansion

should be used with LVP. We recommend large volume paracentesis in one session and discourage repeated low volume paracentesis, which offers no additional benefits and carries a higher risk of procedure-related complications.

Some debate remains over the use of albumin or artificial plasma expanders for volume expansion. Pooled analysis of 10 studies[160–169] found that cirrhotic patients undergoing paracentesis who received albumin were no less likely to develop renal dysfunction than patients undergoing paracentesis that received an alternative plasma expander (pooled RR=1.11, 95% CI 0.58 to 2.14) (online supplemental table 5). Analysis from two other independently conducted systematic reviews is consistent with these findings.[127 128] Pooled analysis from eight studies[160 162–164 166 167 169 170] found that cirrhotic patients undergoing paracentesis who received albumin were no less likely to die than those who received an alternate plasma expander (pooled RR=0.83, 95% CI 0.61 to 1.12) (online supplemental table 6), which is supported by two systematic reviews.[127 128] However, when all comparators to albumin (including control and vasoconstrictor alone) are pooled (16 RCTs) the RR is 0.77 (95% CI 0.57 to 1.00). This translates to 57 to 100 fewer patients per 1000 dying after LVP when HAS is used (online supplemental table 6).

Less clinically important outcomes have been shown to improve in patients treated with HAS versus other plasma expanders. There is a decreased incidence of post-paracentesis-induced circulatory dysfunction (defined as a decrease in plasma renin) in patients undergoing LVP treated with albumin compared with an alternative plasma expander in a meta-analysis containing eight RCTs[127] (OR=0.34, 95% CI 0.23 to 0.51), and a pooled decrease in hyponatraemia in nine RCTs (OR=0.61, 95% CI 0.40 to 0.93).[127] Both are supported in a second independently conducted systematic review.[128]

Most of the plasma expanders used in the described studies are no longer in use and have been restricted by the European Medicines Agency (eg, polygeline carries risk of prion transmission, dextran the risk of allergic reaction and hydroxyethyl starch association with renal impairment and deranged coagulation). Therefore, consensus is that volume expansion should be with HAS due to availability, familiarity of use and suggested benefits in the available studies.

Two small prospective RCTs compared standard dose (6–8 g/L of ascites drained) albumin after LVP with low-dose albumin (2–4 g/L).[171 172] Pooled results from 70 patients suggested no difference in post-paracentesis-induced circulatory dysfunction (RR=2.97, 95% CI 0.89, 9.91) and no development of renal dysfunction (no events in either group). A larger retrospective review of 935 patients found no increase in renal dysfunction when adherence to guidance (8 g/L after 5 L drained) was implemented,[173] but significant cost savings were made because less HAS was used.

Potential cost savings have been proposed in relation to length of hospital stay in patients with ascites undergoing LVP who are treated with HAS as compared with an alternative plasma expander.[166] However, HAS is more expensive than alternatives and is in worldwide shortage, therefore it should be prescribed according to recommended guidance based on the available evidence.[174] There have been no cost-effectiveness analyses in the UK.

Until further studies are undertaken to compare efficacy of albumin against clinically available artificial plasma expanders, we would recommend that albumin remains the preferred plasma expander when paracentesis is undertaken. Albumin (as 20% or 25% solution) should be infused after paracentesis of >5 L is completed at a dose of 8 g albumin/L of ascites removed.

Albumin infusion in SBP

Renal impairment develops in up to 30% of patients with SBP and is one of the strongest predictors of mortality,[175 176] alongside progressive liver dysfunction. Three studies[176–178] have compared albumin with no intervention, and one RCT[179] compared albumin with a plasma expander in order to prevent the development of renal impairment in patients with SBP. Cirrhotic patients with SBP treated with albumin were 72% less likely to develop renal dysfunction than patients with SBP who did not receive albumin (288 patients, pooled RR=0.28, 95% CI 0.16 to 0.50) (online supplemental table 7). There was also a decrease in mortality in patients with SBP treated with albumin, with patients 47% less likely to die than those not receiving albumin (334 patients, pooled RR=0.53, 95% CI 0.36 to 0.79) (online supplemental table 8). Therefore, we recommend the use of albumin in patients with SBP to prevent the development of renal dysfunction and decrease mortality.

Although patients with SBP have a higher risk of post-drain renal dysfunction, LVP is not contraindicated. Therefore, if LVP is indicated in a patient with SBP then this should proceed with HAS support. The dose of albumin in original studies was 1.5 g albumin per kg body weight within 6 hours of diagnosis and 1.0 g/kg on day 3, using estimated dry weight, which is often difficult in cirrhotic patients. Some small studies have suggested that lower doses of albumin are as effective in preventing renal dysfunction and mortality in SBP,[180 181] and one retrospective review including 88 patients with SBP suggested that doses of HAS in excess of 87.5 g (>4×100 mL 20% HAS) are associated with a worse outcome, possibly secondary to fluid overload.[182] Fluid overload has been reported in prospective studies of albumin in patients with cirrhosis and non-SBP infection.[183 184] Therefore, if patients have an increased serum creatinine or a rising serum creatinine, we recommend 1.5 g albumin/kg within 6 hours of diagnosis, followed by 1 g/kg on day 3.

Long term regular outpatient HAS therapy

Improving morbidity and mortality by long-term administration of albumin to patients with decompensated cirrhosis and ascites has been explored in six studies with three recent RCTs, in contrasting patient groups, with contradictory findings (online supplemental table 9).[185–190]

In the ANSWER[185] study, 431 patients with uncomplicated ascites receiving diuretics were randomised to weekly outpatient HAS infusions or no additional intervention (standard medical therapy). The study had a pragmatic approach and was unblinded. Overall 18-month survival was significantly higher in the standard therapy plus HAS than in the standard medical therapy group (Kaplan-Meier estimates 77% vs 66%; p=0.028), resulting in a 38% reduction in the mortality hazard ratio (0.62, 95% CI 0.40 to 0.95). There were additional benefits with lower incidence rate ratio (IRR) for infection (SBP and non-SBP) and renal dysfunction. However, unlike the standard therapy group, the HAS group had weekly medical professional contact when IV albumin was administered which could possibly have caused a confounding effect by improving standard of care in this group.

In the MACHT[186] study, a double-blind, placebo-controlled trial, patients with advanced cirrhosis (MELD score 17–18) awaiting liver transplantation received outpatient fortnightly treatment with midodrine and albumin. This slightly suppressed vasoconstrictor activity but did not prevent complications of cirrhosis or improve survival. However, only nine patients were treated for the entire year, the median length of treatment was only 80 days and the mortality rate in both arms was very low

due to patients undergoing timely liver transplantation. Perhaps, therefore, a greater dose of albumin or longer duration of treatment is required to benefit patients and should be targeted at those who are not close to receiving a liver transplant.

Di Pascoli *et al*[190] most recently published outcomes of a study of 45 patients with refractory ascites undergoing regular LVP who accepted 20 g twice weekly albumin plus diuretics and sodium restriction versus 25 patients who did not (non-randomised, single centre, not blinded). Cumulative incidence of mortality was 41.6% in the albumin group versus 65.5% in the standard of care group. Albumin-treated patients had a lower probability of hospitalisation. There were no differences in the number of LVPs performed. Follow-up was 400 days in the albumin group and 318 in the standard of care group. Although the study was non-randomised (patient choice to treatment arm) it does provide some additional evidence that using albumin in a longer-term outpatient setting may be beneficial, as in the ANSWER study, even in patients with very advanced disease. Two older studies support the use of outpatient albumin therapy in decreasing hospital admissions and LVP requirement with conflicting results on mortality.[187 189]

We expect these studies to stimulate further investigation to determine whether long-term albumin administration is feasible, efficacious and cost-effective in patients with cirrhosis and ascites within the NHS. Further research is required to determine which patients could benefit most from treatment, which seems to be those with less advanced disease who could receive treatment for at least 12 months. At present it is not possible to recommend the use of outpatient albumin administration in patients with ascites due to cirrhosis.

Recommendations

- Albumin (as 20% or 25% solution) should be infused after paracentesis of >5 L is completed at a dose of 8 g albumin/L of ascites removed. (*Quality of evidence: high; Recommendation: strong*)
- Albumin (as 20% or 25% solution) can be considered after paracentesis of <5 L at a dose of 8 g albumin/L of ascites removed in patients with ACLF or high risk of post-paracentesis acute kidney injury. (*Quality of evidence: low; Recommendation: weak*)
- In patients with SBP and an increased serum creatinine or a rising serum creatinine, infusion of 1.5 g albumin/kg within 6 hours of diagnosis, followed by 1 g/kg on day 3, is recommended. (*Quality of evidence: low; Recommendation: weak*)

TRANSJUGULAR INTRAHEPATIC PORTOSYSTEMIC STENT SHUNT (TIPSS)

TIPSS decompresses the portal system by creating an artificial communication between the portal and the hepatic vein. TIPSS results in an increase in cardiac output and decrease in systemic vascular resistance in the short term.[191–193] Consequently, TIPSS leads to improvement in effective hypovolaemia and renal function, resulting in increased urinary sodium excretion.[191–195] The increase in urinary sodium correlates with the reduction in plasma renin activity.[195 196]

The efficacy of TIPSS in the management of ascites has been compared with LVP in seven RCTs (online supplemental table 10).[194 197–202] The first six trials used bare metal stents. Shunt dysfunction due to stent stenosis or thrombosis is a common complication of bare stents and develops in up to 80% of patients.[199 201] The use of polytetrafluoroethylene (PTFE)-covered stents has significantly increased the long-term patency of the stent to 92% at 1 year and 89% at 2 years.[202–204]

TIPSS controls ascites better than LVP. Patients treated with TIPSS are more likely to be free of recurrent ascites than those treated with LVP at 12 months.[205] However, the impact of TIPSS on survival is less consistent. The initial trial by Lebrec *et al*[194] showed a better survival with LVP mainly due to the detrimental effect of TIPSS in Child-Pugh C patients. The subsequent three studies did not show any difference in survival between TIPSS and LVP,[197–199] whereas the most recent three studies have shown improved survival with TIPSS.[200–202] In the two meta-analyses of the six trials using bare stent grafts, Bai *et al*[205] reported an improved transplant-free survival with TIPSS but this was limited to patients with recurrent ascites and not refractory ascites in the other study.[206] All the six trials with bare metal stents consistently showed that TIPSS resulted in higher incidence of hepatic encephalopathy than with LVP.

PTFE-covered stents are now standard of care, and hence the results of the historical RCTs using bare stents are less relevant. Only the most recent RCTs compared PTFE-covered stent with LVP in patients with recurrent ascites. It demonstrated improved 1-year survival with TIPSS without any increased incidence of hepatic encephalopathy.[202]

TIPS has also been shown to improve the quality of life and nutritional status in patients with refractory ascites,[207–209] but the improvement was dependent on the resolution of ascites.

TIPSS technique

A controlled study comparing TIPSS with 8 mm and 10 mm covered stent was stopped early as the 8 mm stent was not effective in controlling portal hypertensive complications (variceal bleeding and ascites).[210] The rate of hepatic encephalopathy was equal between the two groups. However, in another study of variceal bleeding, 8 mm stents were as effective as 10 mm stents in preventing rebleeding, with a 50% reduction in the incidence of encephalopathy with 8 mm stents.[211] Nonetheless, the applicability of these data in patients with refractory ascites is unclear, and evidence suggests that stent diameter increases over time.[212] In a retrospective study of patients with refractory ascites, 10 mm covered stent led to better control of ascites than an 8 mm stent, without any increase in encephalopathy.[213] Data from recent TIPSS registry in Germany reported an improved survival with 8 mm than with 10 mm covered stent.[214] The optimal diameter of covered TIPS stent in refractory ascites remains unclear.

The volume of TIPSS being performed in an individual hospital influences outcomes. Inpatient mortality was significantly lower in centres performing more than 20 TIPS procedures per year.[215]

Patient selection

Careful selection of patients with refractory ascites to be treated with TIPSS is vital to maximise the benefits and reduce the harmful effects of the treatment. The exclusion criteria for the insertion of TIPSS in the seven RCTs are reported in online supplemental table 10.

Patients with advanced stages of cirrhosis have been excluded from the trials as indicated by serum bilirubin,[197–202] prolonged prothrombin time,[198 199] renal dysfunction[194 197 198 200–202] and Child-Pugh score.[200–202] Presence of chronic hepatic encephalopathy was an exclusion criterion in all the RCTs; the presence of pre-TIPS encephalopathy has been shown to be a predictor of poor outcome following TIPSS.[216–218]

In retrospective studies, patients with advanced disease had a worse outcome following TIPS insertion. The MELD score

was originally developed to predict survival following TIPSS and included serum creatinine, bilirubin, INR and aetiology of cirrhosis.[219] The MELD score has now evolved into a prognostic score in patients with cirrhosis.[220] Among patients with refractory ascites treated with TIPSS with covered stent, 1-year survival is 84% in those with MELD score <15 compared with 54% for MELD score >18.[221] In refractory ascites, a simple model of serum bilirubin and platelet count has been shown to predict 1-year survival.[222] The survival rate of patients with serum bilirubin >50 µmol/L or platelet count of $<75\times10^9$/L was only 31.2% compared with 73.1% in patients with serum bilirubin <50 µmol/L and platelet count of $>75\times10^9$/L. The exact survival rate quoted here has to be interpreted cautiously as earlier patients in the cohort were treated with a bare metal stent before the introduction of a PTFE-covered stent. Hyponatraemia has also been shown to be related poor survival following TIPSS,[223] but subsequent studies have not reproduced this finding.[221 224] Up to 50% of patients with decompensated cirrhosis have sarcopenia, which in turn negatively affects clinical outcome in these patients. However, the direct impact of sarcopenia on outcomes following TIPSS is unclear. Sarcopenia has been shown to be independently associated with development of post-TIPSS encephalopathy, but this study included patients with refractory ascites and uncontrolled variceal bleeding.[225] A recent retrospective study published in abstract form on patients undergoing TIPSS for refractory ascites reported no impact of sarcopenia on outcomes after TIPSS.[226] Furthermore, they reported an improvement in muscle mass following TIPSS insertion.

Although increasing age has been associated with poorer survival following TIPSS,[215 227 228] the mean age in these studies was between 54 and 57 years. Patients above the age of 70 were generally excluded from the previously mentioned RCTs. There is a lack of data in the literature for clinical outcome following TIPS in older patients (>70 years). Interestingly, functional disability as measured by patient-reported activities of daily living predicts post-TIPSS mortality adjusted for MELD score.[229]

The management of hepatic encephalopathy after TIPSS is beyond the scope of this document and is discussed in the recent BSG/BASL TIPSS guidelines.

Recommendations

- TIPSS should be considered in patients with refractory ascites. (*Quality of evidence: high; Recommendation: strong*)
- Caution is required if considering TIPSS in patients with age >70 years, serum bilirubin >50 µmol/L, platelet count $<75\times10^9$/L, MELD core ≥18, current hepatic encephalopathy, active infection or hepatorenal syndrome. (*Quality of evidence: moderate; Recommendation: strong*)

MANAGEMENT OF UMBILICAL HERNIA IN PATIENTS WITH ASCITES

In the cirrhotic patient, the incidence of abdominal wall hernia is 16% and reaches 24% in the presence of ascites; more than half of these are umbilical hernias.[230] These progressively enlarge and are prone to complications, including ulceration of the overlying skin, incarceration, strangulation, and rupture. Non-operative management of complicated hernias with antibiotics and dressing changes might result in mortality rates in the range of 60–88%.[231] On the other hand, hernia repair in cirrhosis has often been avoided due to high postoperative morbidity and mortality. Emergency surgery (OR=10.32, 95% CI 3.66 to 47.82), Child-Pugh-Turcotte class C (OR=5.52, 1.67 to 32.45), American Society of Anaesthesiologists (ASA) score ≥3 (OR=8.65, 3.65 to 87.23) and MELD score ≥20 (OR=2.15, 2.71 to 32.68) are associated with mortality.[232]

A recent retrospective series of 102 patients, who underwent surgical repair of the umbilical hernia in the presence of ascites, included 45 patients having emergency surgery (24 with incarceration, 12 with rupture of the hernia sac, and nine with skin ulceration or necrosis). Morbidity and mortality rates of 37.2% and 3.9%, respectively, were observed.[233] Optimising management of ascites, including LVP and TIPSS perioperatively, could reduce the risk of wound dehiscence and recurrence of hernia.[234]

Recommendations

- Suitability and timing of surgical repair of umbilical hernia should be considered in discussion with the patient and multidisciplinary team involving physicians, surgeons and anaesthetists. (*Quality of evidence: low; Recommendation: strong*)

HEPATIC HYDROTHORAX

Hepatic hydrothorax (HH) is accumulation of transudative fluid in the pleural space in the absence of cardiac, pulmonary or pleural disease, affecting approximately 5–12% of patients with advanced liver disease.[235] The first-line management of hydrothorax is based on controlling ascites with diuretics and/or LVP as discussed previously. However, pleural effusion can persist despite successful treatment of ascites, defined as refractory hydrothorax.[47]

Therapeutic thoracentesis is required to provide symptomatic relief from dyspnoea but the effect is transient. Repeated procedures increase the risks of complications, including pneumothorax, bleeding and pleural infection.[236] TIPSS has been suggested either as a definitive treatment or as a bridge to transplantation in patients with refractory hydrothorax. Meta-analysis of six retrospective studies with a total of 198 patients reported a response rate of 56%.[237] Mortality within 45 days of TIPSS placement was 18%, mainly related to older age and the severity of liver disease. However, without any data on comparison with standard treatment, it is difficult to interpret the impact of TIPSS on survival. It is also worth noting that only one of these studies reported on patients treated with PTFE-covered stents.[238] In patients with contraindications to TIPSS or liver transplant, a permanent indwelling pleural catheter can be considered in conjunction with the patient and the multidisciplinary team taking into account the infection risk.

Recommendation

- TIPSS should be considered in patients with HH after discussion with the multidisciplinary team. (*Quality of evidence: low; Recommendation: strong*)
- In patients with HH who are not undergoing a TIPSS and/or a liver transplant evaluation, alternative palliative interventions should be considered. (*Quality of evidence: low; Recommendation: strong*)

NON-SELECTIVE BETA-BLOCKERS AND ASCITES

The portal pressure-lowering effects of non-selective beta-blockers (NSBB) have been known to be beneficial in patients with ascites for three decades. Lebrec's group demonstrated back in 1991 in a meta-analysis of trial data that NSBB reduce the likelihood of first variceal haemorrhage in the ascites subgroup, while in Child's Pugh B and C cirrhosis the addition of NSBB to band ligation results in less variceal rebleeding and superior survival.[239 240] Proven haemodynamic response to NSBB (drop

in hepatic venous pressure gradient (HVPG) of ≥10–20% from baseline, or to <12 mm Hg) has been linked with a lower probability of the development of ascites; and in patients already with ascites, a lower probability of refractory ascites and hepatorenal syndrome.[241 242] However, it remains possible that non-response in this context is simply a surrogate marker for disease severity.

In recent years, there has been increasing recognition that the benefits of NSBB in patients with cirrhosis may not be exclusively explained by the reduction in portal pressure. NSBB reduce markers of intestinal permeability, bacterial translocation, systemic inflammation and the incidence of spontaneous bacterial peritonitis independently of haemodynamic response, suggesting a direct effect, potentially via intestinal transit time or on the bowel mucosal integrity.[243–245] Given the mounting evidence that bacterial translocation and the systemic inflammatory response contribute to the downward spiral of circulatory dysfunction in cirrhosis, it follows that NSBB may also reduce non-bleeding related mortality.[61 246]

Despite all this, Lebrec *et al*[194] introduced controversy to the beta-blocker story in 2010 when his team reported that patients with refractory ascites receiving NSBB had greater all-cause mortality during long-term follow-up.[247] The window hypothesis has since been proposed, which postulates that refractory ascites represents the tipping point in portal hypertension when the cardio-inhibitory effects of NSBB compromise organ perfusion.[246] Krag and coauthors suggest that the 'window' of benefit from NSBB opens when grade 2 oesophageal varices develop and closes with the development of refractory ascites. Yet, concerns have been raised about the methodology of the original observational study; and many subsequent studies, including five meta-analyses and three with propensity risk score matching, have shown either similar or superior survival in patients with refractory ascites receiving NSBB.[175 240 247–253] Of relevance is that the Lebrec data observed patients receiving a relatively high dose of NSBB compared with many of the other cohorts studied, and the NSBB type (carvedilol vs propranolol) may be important.[247 254]

We conclude that, until randomised high-quality data are available, the current evidence supports the use of NSBB when indicated in patients with refractory ascites (online supplemental table 11), unless alternative markers of circulatory failure, such as hypotension or reduced glomerular filtration rate, are present.[175]

Recommendation

- Refractory ascites should not be viewed as a contraindication to NSBB. (*Quality of evidence: moderate; Recommendation: strong*)
- Patients with refractory ascites who are taking NSBB should be monitored closely, and dose reduction or discontinuation may be appropriate in those who develop hypotension or acute/progressive renal dysfunction. (*Quality of evidence: moderate; Recommendation: strong*)

AUTOMATED LOW-FLOW ASCITES PUMP (ALFAPUMP)

The ALFApump system consists of a subcutaneously implanted battery-powered programmable pump. It is connected to catheters that transfer ascites from the peritoneal cavity to the bladder, from which it is eliminated with urine. Initially, two multicentre safety and efficacy studies[255 256] reported substantial reduction of the number and volume of paracenteses in patients with advanced cirrhosis and refractory ascites. However, adverse effects directly related to the device occurred in up to 39% of cases. In a multicentre RCT in patients with refractory ascites, the ALFApump significantly reduced the need for paracentesis and was associated with significantly improved chronic liver disease questionnaire, nutritional parameters such as hand-grip strength and body mass index.[257] Meta-analysis of the data from the RCT and several case series showed that 62% of the patients did not require LVP following pump insertion.[258] Pooled estimate rates were 30% for acute kidney injury, 27% for bacterial peritonitis and 20% for urinary tract infection. The device had no effect on survival. Currently, NICE recommends that the ALFApump should be used only with special arrangements for clinical governance, consent and audit or research.[259]

Recommendation

- Automated low-flow ascites pump should be considered only in special circumstances with robust arrangements of clinical governance, audit or research. (*Quality of evidence: low; Recommendation: weak*)

Hepatorenal syndrome

Patients with cirrhosis and ascites can develop a specific form of renal dysfunction, which is termed hepatorenal syndrome (HRS). Traditionally HRS was thought to be due to the altered haemodynamic alterations with hyperdynamic circulation as well as overactive endogenous vasoactive system which results in renal hypoperfusion.[260] It is now recognised that systemic inflammation also plays an important role in the pathophysiology of HRS.[261 262]

The traditional classification of HRS-1 and HRS-2 has recently been revised by the International Club of Ascites.[263] HRS-1, which reflects a rapid reduction in renal function, has been proposed to be changed to HRS-acute kidney injury (HRS-AKI). The new definition of HRS-AKI includes an increase in serum creatinine of ≥0.3 mg/dL (27 µmol/L) within 48 hours or ≥50% from baseline, without necessitating a final cut-off value of 1.5 mg/dL (133 µmol/L). This allows treatment to be started earlier. HRS-2, which represents renal dysfunction that does not progress rapidly, has been proposed to be changed to HRS-NAKI (non-AKI).[263]

The mainstay of treatment of HRS-AKI involves HAS and vasoconstrictors, particularly terlipressin. Combination of terlipressin and HAS has been shown in RCTs to significantly improve renal function in HRS-AKI and improve short-term mortality (online supplemental table 12).[264–266] Higher baseline serum creatinine is an independent predictor of failure to respond to vasoconstrictor treatment.[262 267] A full review of HRS is beyond the scope of this guideline.

PALLIATIVE CARE

Palliative care is integral to the management of advanced non-cancer conditions, such as cardiac, respiratory and renal disease, often supported by practice guidelines.[268–270] Patients with cirrhosis and ascites often report a poor quality of life,[271] this being an independent predictor of 12-month mortality.[272] However, only a minority of patients with advanced cirrhosis receive timely palliative care and this has been discussed in recent reviews.[273 274] A British study indicated that from 2013 to 2015, of the 45 000 cirrhosis-related deaths, about a third required LVP in the last year of their life, overall healthcare costs being over £21 000 per person.[275]

Substantial literature supports the use of palliative tunnelled long-term abdominal drains (LTAD) in individuals with refractory ascites due to malignancy, including NICE medical technology guidance.[276–279] These drains are inserted in hospital and

allow drainage of small amounts of ascites 2–3 times a week at home. Potential advantages over LVP include symptom-guided drainage and avoidance of repeated hospitalisations. A recent systematic review on LTAD in cirrhosis showed that the majority of patients could be managed in the community.[280]

Results from a recent feasibility RCT comparing palliative LTAD with LVP in refractory ascites due to cirrhosis have just been published (REDUCe study).[281] In this 3-month study, 36 patients were randomised, 19 to LVP and 17 to LTAD. All patients received prophylactic antibiotics for the study duration. Following randomisation, the median number (IQR) of hospital ascitic drains for LTAD versus LVP groups were 0 (0, 1) versus 4 (3, 7), respectively. Only two patients allocated to LTAD required hospital admissions specifically for ascites drainage. Self-limiting cellulitis/leakage occurred in 41% (7/17) in the LTAD vs 11% (2/19) in the LVP group; peritonitis incidence being 6% (1/17) vs 11% (2/19), respectively. Median (IQR) fortnightly community/hospital/social care ascites-related costs were lower in the LTAD group than in the LVP group, £329 (253, 580) versus £843 (603, 1060), respectively. Qualitative data (currently only published as a summary) indicate that LTAD could transform the care pathway.[281]

The REDUCe study demonstrates feasibility, with preliminary evidence of LTAD acceptability, effectiveness and safety and reduction in health resource use. Future trials should assess LTAD as a palliative intervention for refractory ascites in cirrhosis.

Recommendations

- Patients with refractory ascites who are not undergoing evaluation for liver transplant should be offered a palliative care referral. Besides repeated LVP, alternative palliative interventions for refractory ascites should also be considered. (*Quality of evidence: weak; Recommendation: strong*)

CONCLUSIONS

The development of ascites is a landmark in the natural history of cirrhosis. Therefore, it should be considered an important time point at which an individual patient's suitability for liver transplantation which is a definitive treatment of ascites and its complications, should be determined. Over the years, there has been a substantial improvement in care of patients with cirrhosis, including those with ascites. A study involving over 780 000 hospitalisations of patients with cirrhosis demonstrated an improvement in inpatient survival over a decade despite higher age and more medically complex disease.[282] This was remarkably consistent across several cirrhosis complications, suggesting improved cirrhosis care beyond general improvements in inpatient care. Future research should focus on areas of need and questions where there is no high-quality evidence to guide the management of ascites.

RESEARCH RECOMMENDATIONS

- Randomised controlled trials (RCTs) with large sample size should evaluate the role of antibiotics in the secondary prophylaxis for SBP in ascites secondary to cirrhosis.
- Large RCTs should assess the role of midodrine in the management of ascites.
- Cost-effectiveness of long-term administration of HAS to patients with decompensated cirrhosis and ascites should be evaluated.
- Role of nutritional interventions in the management of ascites should be evaluated.
- Large RCT of long-term carvedilol versus no carvedilol in patients with refractory ascites without large oesophageal varices should be carried out.
- Role of TIPSS in the management of hepatic hydrothorax should be compared with other therapeutic interventions.
- The cost-effectiveness and the effect of automated low-flow ascites pumps on the quality of life of patients with refractory ascites should be evaluated.
- Effectiveness and safety of long-term abdominal drains should be assessed in RCTs for the palliative care of patients with cirrhosis and refractory ascites.

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Acknowledgements We are grateful to Shani Steer, voluntary peer mentor, Brighton for her involvement and review of these guidelines. We wish to thank the BSG Liver Section for support and internal review of the guideline. We are grateful to BASL for review and endorsement of this guideline. We also thank Peuish Sugathan and Nottingham University Hospitals NHS Trust for providing data on the underlying aetiology in patients with new onset ascites.

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Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests SV and LM: Received support from Rocket Medical for the NIHR funded REDUCe Study.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information.

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Supplementary Tables

Supplementary table 1: Studies on primary and secondary prophylaxis in SBP, post Cochrane review 2009 (Cohen et al. 2009 Cochrane Database of Systematic Reviews)

Refid	Author	Title	Issue	Journal	Vol	Year	Study participants:	Comment
387	Flamm S.L., Sanyal A.J., Neff G.W., Rolleri R.L., Barrett A.C., Bortey E., Paterson C., Forbes W P (US) Abstract only.	Impact of liver disease status and treatment with rifaximin on complications of cirrhosis in a randomized, placebo-controlled trial	4 SUPPL. 1	Hepatology	58	2013	Cirrhosis with ascites, no gastrointestinal bleeding, no obvious sign of infection at baseline	A post-hoc analysis with much stratification was done and the exact impact on SBP is not clear.
63	Felix Tellez-Avila, Jose Sifuentes-Osornio, Varenka Barbero-Becerra, Ada Franco-Guzman, Roberto Ruiz-Cordero, Roberto Alfaro-Lara, Angeles Hernandez-Ramirez, Florencia Vargas-Vorackova, F Téllez-Ávila, Jose Sifuentes-Osornio, Varenka Barbero-Becerra, A Franco-Guzmán, Roberto Ruiz-Cordero, Roberto Alfaro-Lara, A Hernández-Ramírez, F Vargas-Voráckova (Mexico)	Primary prophylaxis with ciprofloxacin in cirrhotic patients with ascites: a randomized, double blind study.	1	Annals of hepatology	13	2013	Cirrhosis with ascites, no gastrointestinal bleeding, no obvious sign of infection at baseline. Patients were excluded if previous SBP and if ascitic albumin <1.5g/dl.	n=49 ciprofloxacin n=46 placebo Both for 1 month. Conclusion: Primary prophylaxis without an accepted indication did not show a preventative effect on development of bacterial infections at 1-month follow up.
422	Abd-Elsalam S., Ali L.A., Soliman S., Ibrahim S., Elfert A , S Abd-Elsalam, La Ali, S Soliman, S Ibrahim, A Elfert (Egypt)	Randomized controlled trial of rifaximin versus norfloxacin for secondary prophylaxis of spontaneous bacterial peritonitis	2 suppl. 1	Journal of Hepatology Later published in Eur J Gastroenterol Hepatol	64	2016	Cirrhosis with ascites, no gastrointestinal bleeding, no obvious sign of infection at baseline	Rifaximin vs Norfloxacin for secondary prophylaxis. n=262. 6-month follow up. Recurrence of SBP significantly lower in the Rifaximin group.
225	Amr S Hanafy, Ahmad M Hassaneen (Egypt)	Rifaximin and midodrine improve	12	European journal of	28	2016	Cirrhosis with ascites, no gastrointestinal	Looked at Rifaximin and midodrine added to

		clinical outcome in refractory ascites including renal function, weight loss, and short-term survival.		gastroenterology & hepatology			bleeding, no obvious sign of infection at baseline	diuretic therapy compared to standard diuretic therapy and impact on diuresis and short term survival. SBP not an endpoint.
11	S Lontos, E Shelton, Pw Angus, R Vaughan, Sk Roberts, A Gordon, Pj Gow (Australia)	A randomized controlled study of trimethoprim-sulfamethoxazole versus norfloxacin for the prevention of infection in cirrhotic patients	5	Journal of digestive diseases	15	2014	Cirrhosis with ascites, no gastrointestinal bleeding, no obvious sign of infection at baseline	RCT comparing trimetho-sufamethoxazole vs norfloxacin in patients at high risk of SBP. n=80. 12 month follow-up. No significant difference in infection between groups.
58	Markus Casper, Martin Mengel, Christine Fuhrmann, Eva Herrmann, Beate Appenrodt, Peter Schiedermaier, Matthias Reichert, Tony Bruns, Cornelius Engelmann, Frank Grunhage, Frank Lammert, INCA trial group (Germany)	The INCA trial (Impact of NOD2 genotype-guided antibiotic prevention on survival in patients with liver Cirrhosis and Ascites): study protocol for a randomized controlled trial.		Trials	16	2015	Cirrhosis with ascites and gastrointestinal bleeding, no obvious sign of infection at baseline	Patients with NOD2 variants randomized to norfloxacin or placebo as primary prophylaxis. In progress.
59	Tarek Mostafa, Gamal Badra, Mahmoud Abdallah (Egypt)	The efficacy and immunomodulatory effect of rifaximin in prophylaxis of spontaneous bacterial peritonitis in cirrhotic Egyptian patients.	2	The Turkish journal of gastroenterology : the official journal of Turkish Society of	26	2015	Cirrhosis with ascites, no gastrointestinal bleeding, no obvious sign of infection at baseline	Rifaximin vs Norfloxacin as secondary prophylaxis. 6-month treatment. n=70. Less recurrence of SBP in Rifaximin group.

				Gastroenterology				
398	Kimer N., Pedersen J.S., Moller S., Krag A., Bendtsen F (Denmark)	Randomized trial with rifaximin in liver cirrhosis. Effects on the haemodynamic and inflammatory state	SUPPL. 2	Journal of Hepatology	62	2015	Cirrhosis with ascites, no gastrointestinal bleeding, no obvious sign of infection at baseline	Full text below
56	M Assem, M Elsabaawy, M Abdelrashed, S Elemam, S Khodeer, W Hamed, A Abdelaziz, G El-Azab (Egypt)	Efficacy and safety of alternating norfloxacin and rifaximin as primary prophylaxis for spontaneous bacterial peritonitis in cirrhotic ascites: a prospective randomized open-label comparative multicenter study.	2	Hepatology international	10	2016	Cirrhosis with ascites, no gastrointestinal bleeding, no obvious sign of infection at baseline	Compared alternating norfloxacin/rifaximin vs norfloxacin alone vs rifaximin alone as primary prophylaxis in patients at high risk of developing SBP (ascitic protein <1.5 g/dL, CP>9). n=334. 6-month treatment. Alternating treatment showed higher efficacy compared to norfloxacin alone.
428	Hj Yim, Sj Suh, Yk Jung, Sy Yim, Ys Seo, Sy Park, Jy Jang, Ys Kim, Hs Kim, Bi Kim, Sh Um, Yim H.J., Suh S.J., Jung Y.K., Yim S.Y., Seo Y.S., Park S.Y., Jang J.Y., Kim Y.S., Kim H.S., Kim B.I., Um S H (South Korea)	Comparison of daily norfloxacin versus weekly ciprofloxacin for the prevention of spontaneous bacterial peritonitis in cirrhotic patients: A randomized controlled trial	2 suppl. 1	Journal of Hepatology Recently published in Am J Gastroenterol	64	2016	Cirrhosis with ascites and gastrointestinal bleeding, no obvious sign of infection at baseline	Daily norfloxacin vs weekly cipro in patients with previous SBP or deemed to be at high risk with ascitic protein of <1.5 g/dL. n=124. 12 month treatment and follow up. Once weekly ciprofloxacin as effective as daily norfloxacin.

449	Kimer N., Pedersen J.S., Busk T.M., Gluud L.L., Hobolth L., Krag A., Moller S., Bendtsen F , Nina Kimer, Julie Steen Pedersen, Troels Malte Busk, Lise Lotte Gluud, Lise Hobolth, Aleksander Krag, Soren Moller, Flemming Bendtsen, Copenhagen Rifaximin (CoRif) Study Group	Rifaximin has no effect on hemodynamics in decompensated cirrhosis: A randomized, double-blind, placebo-controlled trial.	2	Hepatology	65	2017	Cirrhosis with ascites, no gastrointestinal bleeding, no obvious sign of infection at baseline	Haemodynamic effects of Rifaximin examined (n=45). SBP not an endpoint.
411	Praharaj D., Taneja S., Duseja A., Chawla Y.K., Dhiman R K (India)	Randomized control trial of rifaximin and norfloxacin in primary and secondary prophylaxis of spontaneous bacterial peritonitis (SBP) in cirrhotic patients	Supplement 2	Journal of Clinical and Experimental Hepatology	7	2017	Cirrhosis with ascites, no gastrointestinal bleeding, no obvious sign of infection at baseline	n=59 with previous SBP assigned to receive either norfloxacin or rifaximin. n=58 with ascites and CP>9, no past episode of SBP, assigned to receive either norfloxacin or rifaximin. 6-month treatment/follow up. Rifaximin more effective than norfloxacin in secondary prophylaxis of SBP.

Supplementary Table 2: Studies assessing salt restriction as a therapeutic intervention in controlling ascites in patients with cirrhosis

Author, sample size, study duration Outcome measures	**Study design, method of randomisation, patient, characteristics, study groups**	**Outcomes**
Reynolds T, 1978 N=201 8-27 days No outcome stated	RCT, randomisation method and sample size calculations not stated 90% ALD, non azotemic, no fluid restriction **Study 1** a. Sodium restriction 10 mmol/day + diuretics (ethacrynic acid/spironolactone) until ascites resolution b. Unrestricted sodium diet + diuretics until ascites resolution c. Unrestricted sodium diet + diuretics until partial ascites resolution **Study 2** Similar except furosemide used **Study 3** a. Sodium restriction (as above) + spironolactone and furosemide until ascites resolution b. Unrestricted sodium diet + spironolactone and furosemide until partial ascites resolution	Diuresis and weight loss similar in those with sodium restricted and sodium unrestricted diet. Greater natriuresis in sodium unrestricted diet. Serum sodium fell significantly in all three subgroups receiving a low sodium diet.
Descos L, 1983 N=328 5 days-1 month Outcome not stated	RCT, randomisation method and sample size calculations not stated ALD, 1L fluid blood urea > 8mmol/l excluded Groups 1. Sodium restricted to 500 mg/day + spironolactone 2. Sodium restriction as above + either spironolactone + furosemide or amiloride/hydrochlorothiazide 3. Unrestricted sodium + Spironolactone + furosemide /Moduretic 4. Sodium restriction as above + paracentesis with reinfusion of concentrated ascites 5. Sodium restriction as above + paracentesis with reinfusion of modified ascites 6. Sodium restriction as above + paracentesis	No difference between groups in body weight, abdominal girth, urine volume and partial/ complete regression of ascites. Treatment failure groups 1-6 16.6%, 26.2%,26.7%, 30.6%,21.7% and 38.7% (no difference in salt restricted and unrestricted diets) No differences in groups 1-3 as regards cirrhosis complications and mortality.

Gauthier A, 1986 N=140 90 days Non- azotemic Outcomes: day 14 and 90: ascites disappearance, wt change, nutritional status, cramps, and biochemical data.	RCT, randomisation method and sample size calculations not stated All ALD, blood urea > 8.3mmol/l excluded, fluid restriction 1L Groups 1. Sodium restricted to 21 mmol/day 2. Unrestricted sodium diet Both groups received diuretics (spironolactone or, if necessary, spironolactone + furosemide).	Day 14 Group 1 vs. 2 Day 14 Group 1 vs. 2: Ascites disappearance (complete 42% vs. 23% and partial 57% vs. 61% ns, failure 1% vs. 16% p<0.01), wt change (kg) 8 ± 4.3 vs. 5.4 ± 4 p<0.01, appetite improved 36% vs. 18% p<0.02, serum sodium difference +4 ± 4.3 vs. +2.4 ± 3.6, p=0.025) Day 90 Group 1 vs. 2: ascites disappearance complete 60% vs. 53%, partial 25% vs. 34%, failure 15% vs. 34%; wt change (kg) 5.9 ± 6.9 vs. 6.8 ± 5.6; appetite improved 52% vs. 50%, nutritional status improved 71% vs. 68%, difference in urea, sodium, potassium and albumin (p=ns for all) No actuarial survival difference at day 90 (p=0.15), except if previous GI bleed salt restricted diet favoured survival (p=0.02). Duration of hospitalisation and costs similar in both groups
Bernadi M, 1993 N=115 Study duration not stated Study aim: evaluate therapeutic effectiveness and complication rate of stepped up care including normal or low sodium diet.	RCT with sample size calculations, randomisation by sealed envelope About 50% Child B and 50% Child C, non azotemic, predominantly ALD, 20% had HCC Groups 1.Salt restricted diet (SRD), sodium 40 mmol/day 2. Salt unrestricted diet (SUD), sodium 120 mmol /day Both groups received increasing doses of potassium canrenoate. If no response, furosemide added	Group 1 vs. Group 2: no difference in spontaneous diuresis 10% vs. 8%, need for addition of furosemide 18% vs. 13%, drop outs (2% vs. 2%) and refractory ascites (5% vs. 6%). Univariate analysis showed that type of diet was not associated with differences in treatment response (Wilcoxon p=0.98). On multivariate analysis creatinine clearance and plasma aldosterone were independently predicted response to treatment.
Soulsby C, 1997 Abstract N=6 8 weeks Aim: compare energy and protein intake in low sodium and no added sodium diet	Cross over RCT, randomisation method and sample size calculations not stated Groups 1. SRD, sodium 40 mmol/day 2. No added salt diet, sodium 60-80 mmol /day	In Group 2 degree of ascites unchanged in 5 and increased in 1 patient . Group 1 vs. Group 2, mean energy intake kcal/day (1940 ± 284 vs. 2501 ± 138), protein intake (79 ± 13 g/d vs. 89 ± 13 g/day), weight loss (- 0.4 ± 1.7 kg vs. +1.7 ± 1.4 kg) and mid arm circumference (-0.5 ±1.5 cm vs. +1.0 ± 0.7cm) (p<0.05)
Gu X, 2012 N=200	RCT, no sample size calculations, randomisation by numerical tables	At day 10 Serum sodium (mmol/l)) higher in Group 2 (134 ± 4.03 vs. 137.6 ±

Duration not stated Aim: to compare blood and urine sodium, PRA, angiotensin II, aldosterone, RBF, renal impairment, diuretic effect, serum albumin and volume of ascites.	95% had HBV cirrhosis, 73% CPS C, fluid restriction implemented ? amount Groups 1. SRD, sodium < 85 mmol (<5g NACL) 2. SUD, sodium 85 mmol- 111mmol (5- 6.5g NACL) Both groups received silymarin, IV albumin and spironolactone 40 mg bd and furosemide 20 mg bd	2.24) and lower in Group 1 (134 ± 4.2 vs. 128.9 ± 2.28 (p<0.001) and higher at day 10 in Group 2 vs. Group 1 (p<0.001). Urine sodium (mmol/l) higher in Group 2 (269.2 ± 5.30 vs. 173.2 ± 5.87) with no change in Group 1 (183.1 ± 5.82 vs. 173.2 ± 4.88) (p<0.001) and higher at day 10 in Group 2 vs. Group 1) (p<0.001). PRA, angiotensin II, and aldosterone significantly reduced in Group 2 and significantly higher in Group 1 (p<0.001). RBF significantly increased in Group 2 (p<0.001), no change in Group 1. At day 30 serum albumin (g/L) increased in Group 2 (33.5 ± 1.86 vs. 31 ± 4.42) p<0.001 with no change in Group 1 (31.2 ± 3.31 vs. 30.6 ± 2.84) and higher at day 30 in Group 2 vs. Group 1 (p<0.001). Renal impairment 0% Group 2 vs. 13.8% (n=14) Group 1 (p<0.01), of whom 8 died Group 2 vs. Group 1: ascites disappearance 45% vs. 16% (p<0.001) and time to ascites disappearance shorter (days) (30.2 ± 3.12 vs. 47.2 ± 9.2 (p<0.001) Caloric intake at day 30 higher in Group 2 and no change in Group 1 (1043.15 ± 225.03 vs. 2081 ± 121.19, p<0.001) and 1044 ± 213.1 vs. 1529 ±113.96/), at day 30 higher intake in Group 2 vs. Group 1 (p<0.001).
Sorrentino P, 2012 N=120 One year Primary end points: transplant free survival. Secondary end points: liver related complications (HRS, GIB, HE).	RCT, Sample size calculations done, method of randomisation not stated Refractory ascites, HCV cirrhosis, excluded CPS >11 and serum creatinine <2 mg/dl Group A: Sodium 80 mmol/day + balanced oral diet + Post LVP TPN + late evening protein snack (BCAA) Group B: Sodium as above + balanced oral diet + late evening protein snack (BCAA) Group C: Sodium as above or sodium free diet	Group A vs. B vs. C Survival: 55% vs. 40% vs. 17.5% A vs. B p=0.048, A vs. C p<0.01, B vs. C p=0.046 Complications significantly lower in Groups A and B vs. C HE: 45% vs. 37.5% vs. 77.5% (p<0.01) GIB: 25% vs. 32.5% vs. 52.5% (p<0.01) HRS: 15% vs. 22.5% vs. .37.5% (p<0.01) SBP 17.5% vs. 22.5% vs. 47.5% (p<0.01 Mean LVP/month 1.1 (0.8–2.5) vs. 1.3 (1–2.9) vs., 2.1 (1.5–4) (p <0.01 and p =0.034).
Morando F, 2015 N=120	Non RCT. Interviews with a pre established questionnaire Patients with cirrhosis attending outpatients. Group 1 SRD Group 2 SUD	Group 1 vs. Group 2 mean daily sodium intake (mmol) 79.5 ± 5.5 vs. 205.9 ± 14.1 (p < 0.0001) 30.8% adherent to SRD 45% erroneously thought were on SRD

Aims: assess adherence of patients with cirrhosis and ascites to a moderately low-salt diet. Evaluate the impact of a low-salt diet on total calorie intake and serum sodium concentration.		24% not following SRD Group 1 vs. Group 2 mean daily caloric intake 20% lower (1382.5 vs. 1658.7) ($p<0.05$) with no difference in occurrence of hyponatremia.

ALD alcohol related liver disease; BCAA branched change amino acids; CPS Child-Pugh Score; GIB gastrointestinal bleed; HE hepatic encephalopathy; HBV hepatitis B virus; HCV hepatitis C virus; HCC hepatocellular cancer; HRS hepatorenal syndrome; PRA plasma renin activity; RCT randomised controlled trial; RBF renal blood flow; SRD salt restricted diet; SUD salt unrestricted diet; SBP spontaneous bacterial peritonitis; wt weight, RCT randomised controlled trial

Supplementary Table 3: Randomised controlled trials comparing sequential and combination diuretic therapy in patients with cirrhosis and ascites

Study	**Fogel M, 1981**	**Santos J, 2003**	**Angeli P et al, 2009**
Salt/fluid restriction	87mmol sodium and 2L fluid/day	50 mmol sodium/day	90 mmol sodium/day
Study groups	Sequential: spironolactone followed by furosemide Combination: spironolactone + furosemide Furosemide monotherapy	Sequential: spironolactone followed by furosemide Combination: spironolactone + furosemide	Sequential: potassium canrenoate followed by furosemide Combination: potassium canrenoate + furosemide
Maximum diuretic dose	Spironolactone 400mg and furosemide 400 mg	Spironolactone 400 mg and furosemide 160 mg	Potassium canrenoate 400 mg and furosemide 150 mg
Response definition	Dosage increased until a 0.4-0.8 kg daily diuresis	Decrease of ascites at least to grade 1(ultrasonography but not clinically detectable)	>700 gms weight loss every 3 days
Sample size (n)	90	100	100
Prior ascites	49%	41%	68%
Bilirubin (mg/dl)	6.4 ± 1.3 – 10.9 ± 1.9	2.1 ± 1.3 – 2.3 ± 1.6	1.9 ± 1.5 vs. 2.1 ± 1.2
Prothrombin time % activity	48 ± 3 - 49 ± 4	65 ± 6 - 68 ± 16	49 ± 19 - 50 ± 12
Albumin (gm/dl)	2.17 ± 0.1 – 3.0 + 0.1	2.63 ± 4.2- 2.74 ± 5.2	3.0 ± 3 - 3.2 ± 5
Creatinine mg/dl)	1.0 + 0.1 – 1.1 + 0.1	0.81 ± 0.2 - 0.84 ± 0.2	0.9 ± 0.2 - 0.9 ± 0.2
Child-Pugh Score	Majority Child C	8.9 ± 1.3 - 9.1 ± 1.5	50% Child B and 47% Child C
Response to spironolactone monotherapy	50%	91%	70%
Outcomes Adverse events	Onset of diuresis faster and % body wt loss greater in combination/furosemide monotherapy vs. sequential group (9 ± 1 days vs. 13± 1 days) and (17 ± 2 vs. 12 ± 2) (p <0.05).	Response combination vs. sequential 98% vs. 94% (p=ns) Median response time similar in combination vs. sequential: 9.8 days (4–35) vs.10.3 days (4–32) Adverse reactions similar in both	In combined group - shorter time for ascites resolution (15.5 ± 5.6 vs. 20.7 ± 6.4) days, p < 0.001, - Treatment failures lower (24% vs. 44%, p<0.05) Lower side effects in combined group (20% vs. 38%, p<0.05), especially hyperkalaemia (4% vs.

	Combination group: hyponatraemia and severe hyperkalaemia (p<0.01). Furosemide monotherapy frequent dose increases, need for potassium supplementation HE/marked electrolyte abnormality/HRS occurred in 33/90 (37%) patients	groups though serum potassium higher in sequential group (4.7±0.7 vs. 4.3±0.4 mmol/l, p=0.03. Need for diuretic dose reduction higher in combination group (68% vs. 34%, p=0.002)	18%, p<0.05)

Wt weight, HRS hepatorenal syndrome, HE hepatic encephalopathy

Supplementary table 4: Studies summarising impact of intravenous (IV) human albumin solution (HAS) on hyponatraemia in patients with cirrhosis and ascites (Group 1 received IV HAS vs. Group 2 no IV HAS)

Study characteristics and duration	Sample size and study duration	Child Pugh score (CPS)	Duration diuretics stopped before study	Baseline serum Na (mmol/L)	Salt/ fluid restriction	Impact of IV HAS on serum sodium (mmol/L) (Group 1 vs. Group 2)	Impact of IV HAS on other outcomes
Gines P, 1988 (RCT) Group 1 40 gms IV HAS after each LVP 4 weeks	n=105 with tense ascites, repeated LVP for 4 weeks	Mostly Child C	Six days, but continued after discharge	<135	Na 50 mmol/day If serum Na < 130, 500 ml fluids/day	133 ± 0.7 vs.133 ± 0.7 (ns) and 133 ± 0.9 vs. 131 ± 1.0 (p<0.01)	Group 2 increase in BUN, PRA, and PA (p<0.01)
McCormick P, (1990) Case series	n=4 with tense ascites, some undergoing LVP	Child C	Variable	122-141	Variable	Serum Na improved in 3 patients	NA
Garcia-Compean D, 1993 (RCT) 24 hours	n=35 with tense ascites undergoing LVP	54% Child C	3 days	<135	Na < 50 mmol/day	134 ± 4 vs. 133± 3.5 and 135±5 vs. 133±4 (p=ns)	Decrease in PRA and PA group 1 (p<0.05)
Luca A, 1995 (RCT) Group 1 mean IV HAS 68 ± 44 gms 24 hours	n=18 tense ascites undergoing LVP	Mean CPS 10.4	NA	>135	Na 40 mmol/day	137 ± 6 vs. 136 ± 7 (ns) and 137 ± 7 vs. 133 ± 10 (p=0.02)	Increase in PRA and PA after 24 hours in group 2 (p<0.05)
Jalan R, 2007 (RCT) Group 1 IV HAS 40 gms/day 7 days	n=24 with refractory ascites with last LVP 7 days ago	NA	> 7 days before	<130	Na < 80 mmol/day, fluids 1.5L/day	In group 1 serum sodium improved from 124 (2) to 133 (6)	Group 1 vs. group 2 serious culture positive infection 3/12 vs. 7/12, renal failure/severe HE/in-hospital mortality 1/12 vs. 5/12 (p=0.05)
Bajaj J, 2018 Retrospective cohort study Group 1 IV HAS 225 gms (IQR 100, 400)	n=1126 hospitalised cirrhotic patients,, HAS indications: AKI (52%), SBP (15%),	Mostly Child C	NA	Group 1 128.66 ± 4.69	NA	Group 1 vs. group 2 hyponatremia resolution 85.41% vs. 44.78%, OR: 1.50 (95% CI	Hyponatremia resolution independent predictor of 30 day mortality

16.80 ±18.60 days vs. 9.11 ± 9.67 days	LVP (33%), hyponatremia (29%)			Group 2 129.21 ± 10.50		1.13–2.00), p= 0.0057,	

BUN blood urea nitrogen, PRA plasma renin activity, PA plasma aldosterone, HE hepatic encephalopathy, IV intravenous, HAS human albumin solution, AKI acute kidney injury, LVP large volume paracentesis

Supplementary table 5: Effect of use of HAS on renal dysfunction in patients undergoing large volume paracentesis

Study	Albumin		Control		Weight	Risk Ratio
	Events (renal)	Total	Events (renal)	Total		[95% CI]
IV HAS versus no intervention						
Garcia-Compean et al. (1993)	1	17	2	18	6.3%	0.53 [0.05, 5.32]
Gines et al. (1988)	0	52	7	53	4.2%	0.07 [0.00, 1.16]
Subtotal	*1*	*69*	*9*	*71*	*10.5%*	*0.23 [0.03, 1.64]*
IV HAS versus alternative plasma expander						
Abdel-Khalek and Arif (2010)	1	68	1	67	4.5%	0.99 [0.06, 15.43]
Altman et al. (1998)	0	33	0	27	-	not estimable
Bertran et al. (1991)	1	8	0	9	3.6%	3.33 [0.15, 71.90]
Fassio and Kravetz (1992)	1	21	1	20	4.6%	0.95 [0.06, 14.22]
Garcia-Compean et al. (2002)	7	48	2	48	14.2%	3.50 [0.77, 16.00]
Perez and Silva (1995)	1	8	0	8	3.6%	3.00 [0.14, 64.26]
Moreau et al. (2006)	4	30	8	38	26.1%	0.63 [0.21, 1.90]
Planas et al. (1990)	1	43	1	45	4.5%	1.05 [0.07, 16.21]
Salerno and Incerti (1991)	1	27	1	27	4.6%	1.00 [0.11, 3.55]
Sola-Vera et al. (2003)	2	37	3	35	11.1%	0.63 [0.11, 3.55]
Subtotal	19	323	17	324	76.6%	1.11 [0.58, 2.14]
IV HAS versus vasoconstrictor						
Appenrodt et al. (2008)	0	13	2	11	3.9%	0.17 [0.01, 3.23]
Bari et al. (2012)	0	13	0	12	-	not estimable
Hamdy and MD (2014)	0	25	9	25	4.3%	0.05 [0.00, 0.86]
Moreau et al. (2002)	0	10	0	10	-	not estimable
Singh et al. (2006b) a	1	20	1	20	4.6%	1.00 [0.07, 14.90]
Singh et al. (2006a) b	0	20	0	20	-	not estimable
Singh et al. (2008)	0	20	0	20	-	not estimable
Subtotal	1	121	12	118	12.9%	0.22 [0.04, 1.20]
TOTAL	**21**	**513**	**38**	**513**	**100%**	**0.77 [0.43, 1.38]**

Supplementary table 6: Effect of use of HAS mortality in patients undergoing large volume paracentesis.

Study	Albumin		Control		Weight	Risk Ratio
	Events (death)	Total	Events (death)	Total		[95% CI]
IV HAS versus no intervention						
Arora et al. (2018)	8	30	21	29	13.6%	0.37 [0.20, 0.69]
Garcia-Compean et al. (1993)	0	17	0	18	-	not estimable
Gines et al. (1988)	20	52	16	53	17.8%	1.27 [0.75, 2.17]
Subtotal	*28*	*99*	*37*	*100*	*31.5%*	*0.69 [0.21, 2.34]*
IV HAS versus alternative plasma expander						
Abdel-Khalek and Arif (2010)	7	68	8	67	6.7%	0.86 [0.33, 2.24]
Bertran et al. (1991)	1	8	0	9	0.7%	3.33 [0.15, 71.90]
Fassio and Kravetz (1992)	6	21	7	20	7.4%	0.82 [0.33, 2.01]
Garcia-Compean et al. (2002)	11	48	18	48	13.6%	0.61 [0.32, 1.15]
Moreau et al. (2006)	1	30	3	38	1.3%	0.42 [0.05, 3.86]
Planas et al. (1990)	13	43	17	45	15.4%	0.80 [0.44, 1.44]
Sola-Vera et al. (2003)	1	37	1	35	0.9%	0.95 [0.06, 14.55]
Zhao and LI (2000)	14	36	11	32	13.8%	1.13 [0.60, 2.12]
Subtotal	*54*	*291*	*65*	*294*	*59.8%*	*0.83 [0.61, 1.12]*
IV HAS versus vasoconstrictor						
Appenrodt et al. (2008)	0	13	1	11	0.7%	0.29 [0.01, 6.38]
Bari et al. (2012)	4	13	5	12	5.6%	0.74 [0.26, 2.12]
Hamdy and MD (2014)	0	25	7	25	0.8%	0.07 [0.00, 1.11]
Moreau et al. (2002)	1	10	1	10	1.0%	1.00 [0.07, 13.87]
Singh et al. (2008)	0	20	1	20	0.7%	0.33 [0.01, 7.72]
Subtotal	*5*	*81*	*15*	*78*	*8.7%*	*0.54 [0.23, 1.26]*
TOTAL	**87**	**471**	**117**	**472**	**100.0%**	**0.77 [0.59, 1.00]**

Supplementary Table 7: Effect of use of HAS on renal dysfunction in patients with SBP

Study	Albumin		Control		Weight	Risk Ratio
	Events (renal)	Total	Events (renal)	Total		[95% CI]
IV HAS versus no intervention						
XUE et al. (2002)	5	56	19	56	40.7%	0.26 [0.11, 0.66]
Sort P (1999)	6	63	21	63	48.4%	0.29 [0.12, 0.66]
Chen et al. (2009)	1	15	3	15	7.4%	0.33 [0.04, 2.85]
Subtotal	*12*	*134*	*43*	*134*	*96.4%*	*0.28 [0.15, 0.51]*
IV HAS versus alternative plasma expander						
Fernandez et al. (2005)	0	10	1	10	3.6%	0.33 [0.02, 7.32]
Subtotal	*0*	*10*	*1*	*10*	*3.6%*	*0.33 [0.02, 7.32]*
TOTAL	**12**	**144**	**44**	**144**	**100.0%**	**0.28 [0.16, 0.50]**

Supplementary Table 8: Effect of use of HAS on mortality in SBP

Study	Albumin		Control		Weight	Risk Ratio
	Events (death)	Total	Events (death)	Total		[95% CI]
IV HAS versus no intervention						
Chen et al. (2009)	4	15	6	15	14.0%	0.67 [0.23, 1.89]
Lone (2015)	6	32	8	34	17.2%	0.80 [0.31, 2.04]
Sort P (1999)	14	63	26	63	50.9%	0.54 [0.31, 0.93]
XUE et al. (2002)	5	56	17	56	17.8%	0.29 [0.12, 0.74]
TOTAL	**29**	**166**	**57**	**168**	**100.0%**	**0.53 [0.36, 0.79]**

Supplementary Table 9: Effect of use of outpatient HAS infusions in patients with liver cirrhosis and ascites

Reference	Patients	Intervention (I)	Comparison (C)	Outcomes	Follow up
Gentilini and Laffi [1] Randomised, single centre, non-blinded. Italy	Cirrhosis & 1st onset clinical ascites. Mostly viral hepatitis. Excluded CKD, HF, HCC, Grade 2-4 HE, infection, GI bleeding	n=43 25g albumin/week for 1 year then 25g albumin fortnightly in years 2-3 PLUS diuretics	n=38 Diuretics only	I (n=43) / C (n=38) Ascites recurrence 21 / 31 Episodes of ascites 26 / 36 SBP 1 / 3 Admitted to hospital 22 / 28 Admission episodes 32 / 40 Mortality 11 / 9 Liver transplant 3 / 1	I: 19.5 +/- 1.8 months C: 20.4 +/- 1.5 months Total range 6-36 months
Vizzutti, et al. [2] *Abstract only* Randomised, single centre, non-blinded, Italy	Cirrhosis and ascites Total 175 patients (?numbers in each group)	Albumin infusions, infusion protocol unclear PLUS diuretics	Diuretics alone	I (n=?) / C (n=?) Admission 92% / 62% Ascites recurrence 94% / 51% Total episodes of ascites 113 / 65	I: 20.07 months C: 21.24 months
Romanelli and Giorgio La Villa [3] Randomised, single centre, non-blinded, Italy	Cirrhosis and 1st onset clinical ascites. Aged 35-70years Nearly all HCV Excluded active ETOH, renal failure, refractory ascites, HCC, HE, infection and GI bleeding at baseline	n=54 25g albumin/week for 1 year then 25g albumin fortnightly in years 2-3 PLUS diuretics	n=46 Diuretics only	I (n=54) / C (n=46) Early loss of f/u 9 / 2 Cumulative survival 108 months / 36 months Survival (2yrs) 31 / 11 Liver transplant 1 / 3 Ascites recurrence 21 (31 episodes) / 39 (54 episodes)	Median follow-up was 84 (2-120) months *(not reported between groups)*
Caraceni, et al. [4] Randomised, multi centre, non-blinded, Italy	Cirrhosis and uncomplicated ascites. All treated with >200mg/day antialdosterone and	n=213 40g albumin twice a week for 2 weeks then	n=218 standard medical care	I (n=213) / C (n=218) Death (total) 38 / 46 Liver transplant 19 / 18 TIPS 6 / 8 >3 LVP/month 18 / 42	I: median 17.6 months C: median 11.5 months

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<td>>25mg/day furosemide.
Aetiology: around 1/3 viral, around 1/3 ETOH

Excluded: refractory ascites, TIPS, HCC, previous transplant, active ETOH, extrahepatic organ failure

Mean MELD 12-13</td>
<td>40g albumin weekly for up to 18 months</td>
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<td>
<table>
<tr><td>Any LVP</td><td>71</td><td>116</td></tr>
<tr><td colspan="3">Evaluation according to time spent in study</td></tr>
<tr><td>Mortality (deaths per person per 18months)</td><td>0.27</td><td>0.44</td></tr>
<tr><td>Probability of survival</td><td>77%</td><td>66%</td></tr>
<tr><td>IRR (I vs C)
SBP
non SBP inf
HE (G3-4)
renal dysfunct
low Na</td><td colspan="2">
0·33 (0·19–0·55)
0·70 (0·54–0·90)
0·48 (0·37–0·63)
0·50 (0·39–0·64)
0·51 (0·40–0·67)</td></tr>
</table>
Hospital admissions decreased by 35% in intervention arm.
Serum albumin higher in treatment arm.
</td>
<td>Loss of follow up similar in both arms</td>
</tr>
<tr>
<td>Sola, et al. [5]

Randomised, multi centre, blinded, Spain</td>
<td>Cirrhosis and ascites active on the liver transplant waiting list

Aetiology: 40% ETOH, 30% HCV. MELD 16-17

Excluded patients treated with DAAs</td>
<td>n=87

Midodrine 15-30mg/day (according to BP) PLUS 40g albumin every 15days</td>
<td>n=86

Dual placebo (encapsulated tablet plus infusion of saline in covered bag every 15 days)</td>
<td>
<table>
<tr><td></td><td>I (n=87)</td><td>C (n=86)</td></tr>
<tr><td>Any complication (renalfailure/hyponatraemia/ infection/HE/GI bleed)</td><td>32</td><td>37</td></tr>
<tr><td>Time to 1st complication</td><td>16 days</td><td>26 days</td></tr>
<tr><td>Death</td><td>6</td><td>4</td></tr>
<tr><td>Transplant</td><td>59</td><td>47</td></tr>
</table>
No difference in number of LVP. No effect of post transplant outcome. No difference in serum albumin.
</td>
<td>Median treatment length 80 days
I: median 63 days
C: median 103 days
10% of treatment arm and 23% of control arm completed 1 year study follow up</td>
</tr>
<tr>
<td>Di Pascoli, et al. [6]

Non randomised (patient choice to be part of intervention arm), single centre, non-blinded, Italy</td>
<td>Cirrhosis with refractory ascites undergoing regular LVP.

Aetiology: ≈ 50% viral.

Excluded: HCC beyond Milan criteria</td>
<td>n=45
Patients who accepted the intervention

20g albumin twice weekly plus diuretics and sodium restriction</td>
<td>n=25
Patients who did not accept the intervention

Standard of care</td>
<td>
<table>
<tr><td></td><td>I (n=45)</td><td>C (n=25)</td></tr>
<tr><td>Mortality (at 2 years)</td><td>15</td><td>15</td></tr>
<tr><td>Cumalative incidence of mortality</td><td>41.6%</td><td>65.5%</td></tr>
<tr><td>Liver transplant</td><td>5</td><td>2</td></tr>
<tr><td>No admission during follow up</td><td>100%</td><td>66%</td></tr>
<tr><td>SBP</td><td>1</td><td>1</td></tr>
</table>
Lower probability of hospitalization in treatment group
No difference in the number or volume of LVP
</td>
<td>I: 400 days

C: 318 days

Loss of follow up not reported</td>
</tr>
</table>

Supplementary Table 10: RCTs comparing TIPS with LVP in patients with refractory ascites and cirrhosis

		Patients enrolled (N)		Ascites improved, %		Survival, %		HE, %		Stent failure	Notes
	Exclusions	TIPS	LVP	TIPS	LVP	TIPS	LVP	TIPS	LVP		
Lebrec 1996	Age >70 HE Severe other. Disease Pulmonary hypertension HCC Sepsis SBP Severe alcoholic hepatitis PV/HV/HA obstruction Biliary obstruction Cr >150	13	12	38	0	29	60	23	0	TIPS was not successful in 3 patients. 3 patients (30%) who had TIPS developed shunt obstruction.	All beta-blockers were stopped. 32% Child C patients. Following TIPS, IV heparin given for 3 days and Ofloxacin 400mg/day for 3 days
				4 months		2-year (p=0.03)					
				23	8						
				1 year							
Rossle 2000	HE Bilirubin >86 μmol/L Creatinine >265 μmol/L PV thrombus Hepatic hydrothorax Advanced cancer Failure of LVP (ascites persisting after LVP or need more than 1 LVP/week)	29	31	61	18	69	52	58	48	13 (45%) patients had shunt insufficiency, 11 patients underwent shunt reestablishment.	30% Child C patients. Following TIPS, IV heparin for 1 week followed by LMWH for 4 weeks. 45% recidivant ascites
				3 months		1-year					
				79	24	58	32	Shunt flow reduced in 3 patients with debilitating HE.			
				6 months		2-year (p=0.11)					

<table>
<tr><td rowspan="4">Gines 2002</td><td rowspan="4">Age <18, >75
Bilirubin >171 μmol/L
INR >2.5
Platelet <40,000/mm^3
Creatinine >265 μmol/L
HCC
PV thrombus
Cardiac/respiratory failure
Organic renal failure
Bacterial infection
Chronic HE</td><td rowspan="4">35</td><td rowspan="4">35</td><td>51</td><td>17</td><td>41</td><td>35</td><td colspan="2">Moderate</td><td rowspan="4">TIPS unsuccessful in 1 patient.
After shunt insertion, complete obstruction occurred in1 patient and could not be repermeablised.</td><td rowspan="4">40% Child C patients.
TIPS was done to reduce portocaval pressure gradient (PPG) below 12 mmHg.</td></tr>
<tr><td colspan="2" rowspan="3">Approx 10 months</td><td colspan="2">1-year</td><td>51</td><td>40</td></tr>
<tr><td>26</td><td>30</td><td colspan="2">Severe (p=0.03)</td></tr>
<tr><td colspan="2">2-year (p=0.51)</td><td>60</td><td>34</td></tr>
<tr><td>Sanyal 2003</td><td>Other causes of ascites than cirrhosis
Incurable cancer
Non-hepatic systemic disease with life expectancy <1 year</td><td>52</td><td>57</td><td>58</td><td>16</td><td>58</td><td>65</td><td>42</td><td>23</td><td>1 patient shunt thrombosis – treated with thrombolysis and anticoagulation.</td><td></td></tr>
</table>

	Bilirubin >85 μmol/L INR >2 Congestive cardiac failure Acute renal failure Parenchymal renal disease PV thrombosis Active sepsis Active HE Florid alcoholic hepatitis HCC GI haemorrhage within 6 weeks of randomisation			1-year		2-year (p=0.8)				Shunt stenosis – 53% at 6 months and 70% at 12 months.	
Salerno 2004	Age >72 Recurrent HE Bilirubin >103 μmol/L Creatinine >265 μmol/L Child Pugh >11 PV thrombosis HCC Recent GI bleeding Serious cardiorespiratory dysfunction Ongoing bacterial infection SAAG <11g/L	33	33	79	43	77	52	61	39	Shunt insufficiency 23% at 1 year and 66% at 2 years. Complete TIPS obstruction in 2 patients.	76% Child C (but no CP>11) Included recidivant ascites (32%)
						1-year					
						59	29	One patient required reduction of stent size.			
						2-year (p=0.021)					
Narahara 2011	Age >70 Child Pugh >11 Bilirubin > 51 μmol/L	30	30	87	9	97	77	67	17	86% (26 patients) developed shunt dysfuntion.	Japanese study TIPS done to achieve portosystemic gradient of below 12mmHg

<table>
<tr><td rowspan="9"></td><td rowspan="9">Creatinine >168 µmol/L
HCC
PV thrombosis
Chronic HE
Active infection
Cardiorespiratory disease
Organic renal disease</td><td rowspan="9"></td><td rowspan="9"></td><td colspan="2">3 months</td><td colspan="2">3 months</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="9">More than 2 revisions required in 20 patients.</td><td rowspan="9">33% Childs C
Patients with good hepatic and renal function.</td></tr>
<tr><td>80</td><td>27</td><td>87</td><td>60</td></tr>
<tr><td colspan="2">6 months</td><td colspan="2">6 months</td></tr>
<tr><td>67</td><td>27</td><td>70</td><td>37</td><td rowspan="5" colspan="2">No shunt reversal carried out for HE</td></tr>
<tr><td colspan="2">1-year</td><td colspan="2">1-year</td></tr>
<tr><td>40</td><td>17</td><td>40</td><td>20</td></tr>
<tr><td colspan="2">2-year</td><td colspan="2">2-year (p<0.005)</td></tr>
<tr><td colspan="10"></td></tr>
<tr><td colspan="10">Covered stent</td></tr>
</table>

Bureau 2017	Age >70 More than 6 LVPs in 3 months OLT expected in the next 6 months or on waiting list CCF Pulmonary hypertension PV thrombosis Recurrent HE HCC Bilirubin>100 μmol/L Child Pugh >12 Creatinine >250 μmol/L Sepsis	29	33	52	0	93	52	34	33	1 patient (3%) developed stent thrombosis	34% Child C
				1-year P<0.05		1-year P=0.003		1 patient had TIPS reduction for recurrent OHE			

Supplementary Table 11: Impact of beta-blockers on clinical outcomes in patients with ascites.

Impact of beta-blockers on survival in patients with ascites:							
Paper	Year	Journal	Country	Description	Nos	Outcomes	Comments
Borroni G	2002	J Hep	Italy	RCT nadolol vs ISMN for prevention of variceal haemorrhage in patients with ascites.	27 vs 27	Nadolol was associated with a reduced variceal bleeding rate, but similar survival to ISMN arm.	Mean 23 months FU. CPS 8. No difference at baseline. Refractory ascitics excluded. 6 nadolol and 4 ISMN patients stopped treatment due to adverse effects within median 4 weeks.
Serste T	2010	Hepatology	France	Prospective observational study of patients hospitalised with refractory ascites. Of the 77 patients on NSBB (100% propranolol), 50% 160mg per day.	151	NSBB patients had a lower probability of survival at 1 year on univariate analysis and after adjusting for CP class, HCC and "aetiology of refractory ascites".	Not matched at baseline – NSBB group were more likely to have OV and had a higher bilirubin; and had a trend towards a higher CP grade, lower Na and greater % of HCC. Lack of consecutive patients. 26 patients transplanted and 13 had HCC – no competing risk analysis No diff in HVPG NSBB vs no NSBB, in the subgroup of patients with measurements (n=50). Causes of death not clearly stated for the NSBB and non NSBB groups.

Galbois A	2011	Hepatology (letter)	France	68 patients with cirrhosis admitted to ITU with severe sepsis/septic shock.	68	Mortality rate in ICU similar for NSBB and non NSBB at 60%. 6 month mortality rate of survivors of ITU was higher in the NSBB group.	Patients on beta-blockers preadmission (not specified NSBB) had a trend towards a higher baseline serum Na, higher MAP and lower HR. (Not clear that they were discharged on NSBB!) Small nos not allowing adjusted analysis.
Mandorfer M	2014	Gastroe -nterology	Austria	Retrospective review of consecutive patients admitted for first LVP. 245 on NSBB – >70% propranolol (70% 60mg or less); most 6.25-12.5 carvedilol. FU largely to ~ 3 years.	607	No difference in variceal bleed rate during FU. NSBB - higher adjusted transplant free survival. But once a patient developed SBP – NSBB associated with a lower transplant free survival (n=182) – but higher bilirubin. NSBB patients were more likely to develop HRS during the 90 days after SBP diagnosis.	No competing risk analysis (censored at transplant – 10%). Higher baseline bilirubin level (and trend towards greater proportion of CPC) in the SBP patients on NSBB vs noNSBB. And during survival analysis adjusted for CPB/C (binary) and varices – but not bilirubin, which would have made sense. Not clear if patients were on NSBB at discharge.
Leithead	2015	Gut	Brum, UK	Retrospective, patients listed for liver transplantation. 117 RA.	322	Overall in all ascitics NSBB had similar mortality to NSBB. In PRS matched ascitics, NSBB were less likely to die on list and more likely to reach transplantation; and in RA, NSBB reduced associated with less wait list death.	Competing risk and PRS matched. Matched on PRS.

				119 prop, 40 carv			
Aday AW	2016	Am J Med Sciences	USA	Retrospective, hospitalised patients with cirrhosis. 43% on NSBB at admission. Primary outcome measure – all cause inhospital mortality	1500 with asci -tes	After adjusting for MELD, NSBB use had a massively reduced HR for inhospital mortality for all commers including non ascitic (ie upper limit of range <0.5, lower limit not visible on diagram). On univariate analysis of patients with any ascites, and then mild and severe ascites, NSBB associated with reduced inhospital mortality.	Only 12% inhospital mortality rate – lower than expected? Unusual way of presenting data. Multivariate analysis included MELD plus components of MELD separately (bilirubin, INR, creat)…. Baseline data not adequately provided. Similar results in subgroup analysis of all commers including only PRS matched. Data not provided.
Bang	2016	Liver Int	Danish	Retrospective study of patients with ascites. Ultimately 3719 patients with decompensated cirrhosis (ie had been treated with paracentesis) identified via the Danish National Patient Register.		For both mildly decompensated and severely decompensated patients, NSBB use was associated with reduced mortality during FU (in the whole cohort adjusted for PRS, and in PRS matched cohort only). In severely decompensated only, NSBB use was associated with a lower incidence of "peritonitis". Apparent dose dependent effect – if propranolol dose >160mg per day any benefit was lost (ie survival was comparable to no NSBB). But no matching for this	National register data with typical data limitations. PRS matched cohort. But even after matching not similar at baseline – NSBB group were more likely to be on diuretics and were less likely to have had a variceal bleed. Lots of subgroup analysis without baseline data and issues with timing of prescription of NSBB in relation to events.

				Mildly decompensated = 1st paracentesis. Severely decompensated = 4th paracentesis. Propranolol users (20%) – minimum of 2 issues of prescription for >1 month. Median dose 100mg per day. FU limited to 2 years.		cohort and no baseline data provided for the subgroups. No impact on incidence of HRS. Amongst the patients who developed peritonitis, those on NSBB had reduced long term mortality (median time from peritonitis to first prescription collection 50 days). Propranolol use prior to peritonitis had no impact on mortality thereafter.	Difficult to interpret.
Njei B	2016	Gut	USA	Letter – metaanalysis of 9 observational studies of patients with ascites that documented NSBB subtype		6 studies including propranolol (dose 40-320), 2 nadolol (60-120) and 2 carvedilol (6.25-12.5) Overall NSBB had no impact on mortality. Propranolol/nad no incease; but carvedilol increase	No individual patient data and simple stats.
Bossen L	2016	Hepatology	Danish	Post hoc analysis of 3 satavaptan RCTs. Diuretic controlled to refractory.	1198	All cause and cirrhosis-related mortality similar for NSBB and non NSBB based on at trial inclusion both for all ascites – and the subgroup of refractory ascitics. (patients who stopped the NSBB had high mortality thereafter and reason for stopping was deterioration)	Reasonably matched at baseline – but slightly less likely to have hyponatraemia or ascites.

				Info not provided on NSBB subtype.			
R Mookerjee	2016	J Hep	EASL-CLIF	Data from CANIONIC study – prospectively collected, 1349 cirrhotic patients. 47% on NSBBs – 68% of whom propranolol, median dose 40mg then mixture for the rest. 95% had ascites – but main defining factor – ACLF.	349 with ACLF	The "NSBB" patients (1/2 of whom had stopped the NSBB pre study inclusion i.e. had been on NSBB within 3 months of diagnosis of ACLF) were less likely to evolve to a more severe grade of ACLF, and had superior 28 day survival on univariate analysis. No multivariate analysis – but for similar CLIF-C ACLF scores, patients on NSBB had a lower probability of death. NSBB was found to be linked with reduced 28 day mortality after LR analysis adjusted for age, presence of previous decompensations and active alcohol consumptions (just). CLIF score, MELD etc not included. 28-day and 3-month mortality was significantly higher in patients who stopped NSBBs vs those that continued.	NSBB group older, were more likely to have had previous decompensations including bleeding, were less likely to have cerebral or coagulation organ failure (with a trend towards less renal failure), had a trend towards a lower MELD (but only just 29 vs 27), had a lower bilirubin, WCC and higher Na, and a lower ACLF grade. **78/164 NSBB patients had the drug stopped prior to inclusion in the study**, and 8 had the dose reduced. But the baseline data and analyses includes these patients (ie who were no longer on NSBB). Presumably patients stopped NSBBs because they were sicker… - the patients who stopped NSBBs were more likely to have circulatory or lung failure and had a higher CLIF-C ACLF score. Low dose propranolol.
Madsen BS	2016	J Hep (letter)	Denmark	Retrospective, first dose SBP and with 12 months FU.	81	Low dose NSBB (80mg) associated with improved survival on adjusted analysis after diagnosis of SBP; high dose NSBB no difference from patients on no NSBB.	Not disclosed how many had active ascites. Minimal stats provided, and median survival for the non NSBB group was only 20 days,

							and for the high dose NSBB group 8 days. Does not add to literature.
Chirapong -sathorn S	2016	Clin Gastroent -terol Hepatol	USA	Metaanalysis of 3 RCTs and 8 observational studies focusing on impact of NSBB on mortality in patients with refractory ascites.	3145 any, 443 RA	NSBBs not associated with increased all-cause mortality. Results were consistent between RCTs and observational studies. And no increase in either RA or non RA groups.	Significant heterogeneity. One of the RCTs had RA as an exclusion criteria.
Sinha R	2017	J Hep	RIE, UK	Retrospective, hospitalised patients with cirrhoisis and ascites. 132 on carvedilol, median dose 12.5mg. 24% severe ascites.	325, 264 PRS	Overall cohort – NSBB patietns had superior survival. In severe ascites NSBB and non NSBB patients had similar survival. Conclusion long term carvedilol not detrimental in decompensated patients with ascites.	Median FU > 2 years. PRS matching – matched at baseline. 50% ALD – no info on abstinence.
Onali S	2017	Liver Int	RFH, UK	Retrospective, cirrhosis with ascites undergoing liver transplant assessment. 92% propranolol (median dose 80mg), 8% carv (6.25mg).	316, 124 RA	In whole cohort – NSBB associated with reduced HR death (adj cox regression competing risk) (but not when analysis repeated in PRS matched patietns where no assocation), and in those with RA when only PRS matched patients included (but not when unmatched, all patietns with RA).	Competing risk analysis and PRS. 17 TIPSS patients included in the PRS cohort. After matching – not quite matched. Sig difference in varices and TIPSS, with a trend towards increased CP grade in nonNSBB patients.

				After PRS matching 106:106			
Bhutta AQ	2017	AP&T	USA	Subanalysis of NACSELD database – patients hospitalised with cirrhosis. 43% on NSBB, 51% refractory ascites.	716	NSBB did not impact on survival (Cox regression) in the whole cohort or the RA group. BB stopped 49% - sicker patients, infection, AKI. Stopping NSBB had no impact on short term survival. BB reinitiated in 40%.	Acutely unwell. Followed up to death or hospital discharge. 62/307 patients classified as being on a betablocker were actually on a selective BB! And still included in the analysis. Not matched at baseline in particular re comorbidity and HCC. BB patients with RA had a lower creat and MELD. Multicentre – different practice between units. Bottom line, low quality.
Albillos A	2017	Hepatology	Spain	Meta-analysis of 6RCTs of patients receiving secondary prophylaxis. 3 studies propranolol 50-120mg/day +/- ISMN; 5 studies nadolol.	800	416 patients VBL/BB vs VBL (as opposed to VBL/BB vs BB). 312 of these patients were CPB/C. Addition of BB to VBL in CPB/C patients resulted in reduced rebleeding and mortality.	One RCT excluded RA. FU 14-23 months.
Facciorusso A	2018	Dig Dis Sci	Multiple led by Italy	Metaanalysis of 16 studies, including 3 RCTs (vs VBL/TIPSS) – patients with	8279	No difference in survival overall, or inpatients with refractory ascites specifically. No difference in SBP or HRS rates.	Marked heterogeneity of studies. RCTs:

				cirrhosis and ascites. 3604 on NSBB, 1994-2015. Mixed NSBB. 6 studies with info on refractory ascites.			Escorsell 2002 – TIPSS vs propranolol for preventing variceal rebleeding (RA not reported); Lo 2004 – VBL vs nadolol for primary prophylaxis (RA excluded); Shah 2014 carvedilol vs VBL for primary prophylaxis (RA not reported); and then the Bossen pulled vaptan trials as above.
Wong RJ	2019	Liver Int	USA	Metaanalysis of 8 observational studies – NSBB vs not in patients with ascites. Primary outcome all cause mortality 1630 NSBB, 1997 not.	3627	No diff in survival for NSBB vs no NSBB groups, including in the subgroup of patients with refractory ascites ie no harm.	"However, significant heterogeneity between studies was observed and our overall GRADE assessment rating of the certainty of the evi- dence was 'very low'"
Tergast	2019	AP&T	Germ	Retrospective, patients hospitalised with ascites requiring paracentesis, 45% refractory Prop/carv – n=255	624	28 day liver transplant free survival greater in patients already on NSBB (including in in SBP and ACLF subgroups). The superior survival benefit was not seen in patients with a MAP<65 where no difference (including in SBP and ACLF subgroups. Notably not detrimental).	NSBB arm had a lower bil at baseline (and were more likely to have varices). Patients had been acutely admitted to hospital – low MAP will have been representative of acute illness. (30% had AKI)

				Median dose propranolol (n=147) 30mg/day; carvedilol (n=108) 12.5mg/d.		In patients with SBP and MAP<65, NSBB was associated with a rise in serum creat from baseline (not seen in no NSBB arm).	Competing risk Short term FU
Ngwa T	2020	BMC Gastro	USA	Retrospective; patients referred for liver transplant 65 on NSBB (prop/carv/nad) – median propranolol dose 20mg od. 25% no ascites, 23% refractory 157/245 nadolol, 65 prop, 23 carv.	170	NSBB arm – lower 90 day mortality. NSBB independently associated with better 90/7 survival on competing risk analysis	NSBB patients were more likely to develop AKI within 90 days but not matched and sicker at baseline. Why was 90 day outcome selected
Yoo JJ	2020	Medicine (Baltimore)	Korea	Retrospective; CPB/C with ascites. PRS analysis. Gd 1/2/3 varices – primary prophlaxis VBL/Propranolol (176) vs VBL alone (95) 80% gd 2 ascites, 20% gd 3 70% propranolol <80mg per day	271	The VBL/propranolol arm had increased mortality secondary to "hepatic failure" – despite similar rates of bleeding, HRS, SBP. Dose of NSBB not relevant.	Only removed 20 patients with PRS matching despite the 2 unmatched cohorts being sig different at baseline. And not 1:1 matched as stated in methods.
Impact of betablockers on variceal bleeding in patients with ascites:							

Paper	Year	Journal	Country	Description	Nos	Outcomes	Comments
Poynard T	1991	NEJM	France Italy	Meta-analysis of 4 RCTs of NSBB for primary prophylaxis. 2 propranolol; 2 nadolol. ~50% no ascites, ~30% mild ascites, and <20% severe ascites. (Undefined).	589	Patients with ascites who were randomised to the NSBB arm were less likely to have a variceal bleed during 2 years FU.	Individual patient data. 3 of the 4 RCTs excluded patients with intractable ascites; and 1 excluded CPS >13.
Bernard B	1997	Hepatology	France	Meta-analysis of 12 RCTs of NSBB for secondary prophylaxis	~800	Ascites not mentioned – but 20-90% CP B/C. Overall, NSBB reduced the rebleeding rate, mortality rate and bleeding related mortality.	Difficult to draw conclusions given ascites not mentioned.
Borroni G	2002	J Hep	Italy	RCT nadolol vs ISMN for prevention of variceal haemorrhage in patients with ascites	27 vs 27	Nadolol was associated with a reduced variceal bleeding rate, but similar survival to ISMN arm.	Mean 23 months FU. CPS 8. No difference at baseline. Refractory ascitics excluded. 6 nadolol and 4 ISMN patients stopped treatment due to adverse effects within median 4 weeks.
Albillos A	2017	Hepatology	Spain	Meta-analysis of 6RCTs of patients receiving secondary prophylaxis.	800	416 patients VBL/BB vs VBL (as opposed to VBL/BB vs BB). 312 of these patients were CPB/C.	One RCT excluded RA. FU 14-23 months.

				3 studies propranolol 50-120mg/day +/- ISMN; 5 studies nadolol.		Addition of BB to VBL in CPB/C patients resulted in reduced rebleeding and mortality.	
Yoo JJ	2020	Medicine (Baltimore)	Korea	Retrospective; CPB/C with ascites. PRS analysis. Gd 1/2/3 varices – primary prophylaxis VBL/Propranolol (176) vs VBL alone (95) 80% gd 2 ascites, 20% gd 3 70% propranolol <80mg per day	271	The VBL/propranolol arm had increased mortality secondary to "hepatic failure" – despite similar rates of bleeding, HRS, SBP. Dose of NSBB not relevant.	Only removed 20 patients with PRS matching despite the 2 unmatched cohorts being sig different at baseline. And not 1:1 matched as stated in methods.
Impact of beta-blockers on SBP in patients with ascites:							
Paper	Year	Journal	Country	Description	Nos	Outcomes	Comments
Soylu AR	2003	Am J Gastro (letter)	Turkey	Retrospective study of patients with ascites. 36 propranolol – mean dose 28mg/day.	73	Incidence of SBP no different between NSBB and no NSBB.	Small no (36 on NSBB), low dose and relatively short FU for mean 6 months. Relatively high rate of SBP Crude stats – univariate analysis of primary outcome measure only and no adjustment for FU (chi square!).

Villaneuva C	2004	J Hep	Spain	Prospective long term study of patients receiving nadololol and ISMN as secondary prophylaxis of variceal haemorrhage. Response defined as HVPG<12 or >20% reduction from baseline	132	The probability of developing ascites, HRS or SBP was less in the responders. The haemodynamic response was maintained to 12-18 months in 81%.	Crude stats – minimal adjustment for duration of FU/confounders. Response may reflect earlier in disease spectrum hence less development of complications.
Senzolo M	2009	Liver Int	UK, RFH	Metaanalysis of primary and secondary prophylaxis of variceal haemorrhage trials looking at impact of NSBB on SBP incidence. Included 3 RCTs and 2 retrospective where SBP as outcome reported. RCTs – 30-60% patients had ascites at entry. Retrospective studies 100% had ascites. 257 propranolol – 94 haemodynamic responders.	644 (374 in RCT)	NSBB reduced the incidence of SBP – including when only RCTs reviewed. Effect also seen in haemodynamic response vs not.	FU 23-76 months; 112 SBP episodes. Not all had ascites, and no subgroup analysis of ascites patients.

				Dose NSBB not given.			
Reiberger T	2013	J Hep	Austria/ Germ	Prospective study of impact of starting NSBB on intestinal permeability.	50	High portal pressure was associated with increased markers of intestinal permeability and bacterial translocation (LPS and IL-6); and NSBB resulted in reduced intestinal permeability and bacterial translocation (not limited to haemodynamic responders).	18% had ascites. Largely CPA but 70% HVPG >20.
Gimenez P	2018	Liver Int	Spain	Prospective, cirrhotics with acute ascites decompensation. Not randomised – 30 already on NSBB. 10/30 propranolol <60mg/day, 2 higher than 80mg/day.	63	No difference in bacterial DNA in blood NSBB vs noNSBB. Concluded "in patients with cirrhosis, chronic treatment with beta-blockers is associated with a higher unstimulated production of serum cytokines and an increased phagocytic activity in the presence of bacterial DNA."	Not matched at baseline. NSBB patients – younger, were more likely to have varices, had a trend towards a higher albumin. Note higher LPS in NSBB patients who did not have bacterial DNA detected – ie difficult to read too much into this study.
Yoo JJ	2020	Medicine (Baltimore)	Korea	Retrospective; CPB/C with ascites. PRS analysis. Gd 1/2/3 varices – primary prophylaxis VBL/Propranolol (176) vs VBL alone (95) 80% gd 2 ascites, 20% gd 3	271	The VBL/propranolol arm had increased mortality secondary to "hepatic failure" – despite similar rates of bleeding, HRS, SBP. Dose of NSBB not relevant.	Only removed 20 patients with PRS matching despite the 2 unmatched cohorts being sig different at baseline. And not 1:1 matched as stated in methods.

				70% propranolol <80mg per day			
Impact of betablockers on kidneys in patients with ascites:							
Villaneuva C	2004	J Hep	Spain	Prospective long term study of patients receiving nadololol and ISMN as secondary prophylaxis of variceal haemorrhage. Response defined as HVPG<12 or >20% reduction from baseline	132	The probability of developing ascites, HRS or SBP was less in the responders. The haemodynamic response was maintained to 12-18 months in 81%.	Crude stats – minimal adjustment for duration of FU/confounders. Response may reflect earlier in disease spectrum hence less development of complications.
Serste T	2011	J Hep	France	Prospective study of impact of NSBB withdrawal on development of PICD in patients with refractory ascites. Patients acted as their own controls. PICD defined as increase in PRA by >50% 1 week after LVP. NSBB = propranolol – 7/10 160mg per day.	10	Whilst on NSBB, paracentesis associated with no change in HR (increased in 9/10 but not sig), but immediate sig drop in systolic BP that returned to baseline by 1 week and 8/10 fulfilled criteria for PICD. Off NSBB, paracentesis resulted also in drop in SBP that returned to baseline but also sig increase in HR. Only 1/10 PICD. No long term data.	Delay between the 2 evaluations mean 3.4 months, but up to 5 – progressive liver disease could have influenced results (?? blunted PRA response on later disease - systolic BP did not seem to bounce back to baseline post paracentesis after NSBB withdrawal compared to when on NSBB; BP still dropped when off NSBB despite HR response). NB sig rise in prothrombin time. 4 patients did not undergo large volume paracentesis during the second study (ie off NSBB). PICD development did not seem to correlate with baseline PRA.

							And baseline PRA did not change with stopping NSBB. Small nos. No patient fulfilled criteria for type 2 HRS or had hypotension at time of paracentesis. No control group who did not change NSBB status but underwent 2 paracenteses.
Mandorfer M	2014	Gastroenterology	Austria	Retrospective review of consecutive patients admitted for first LVP. 245 on NSBB – >70% propranolol (70% 60mg or less); most 6.25-12.5 carvedilol. FU largely to ~ 3 years.	607	No difference in variceal bleed rate during FU. NSBB - higher adjusted transplant free survival. But once a patient developed SBP – NSBB associated with a lower transplant free survival (n=182) – but higher bilirubin. NSBB patients were more likely to develop HRS during the 90 days after SBP diagnosis.	No competing risk analysis (censored at transplant – 10%). Higher baseline bilirubin level (and trend towards greater proportion of CPC) in the SBP patients on NSBB vs noNSBB. And during survival analysis adjusted for CPB/C (binary) and varices – but not bilirubin, which would have made sense. Not clear if patients were on NSBB at discharge.
Serste T	2015	Liver Int	France	Retrospective study of patients with AAH. 60% ascites (no mention of severity). 48/139 NSBB (propranolol, 80%	139	NSBB patients had increased probability of the development of AKI during the subsequent ~30 days (including after adjusted for MELD), but no sig increase in mortality.	NSBB arm had a trend towards a higher baseline serum creatinine, and were more likely to have varices and a previous variceal haemorrhage/severe AAH (potential significant of pre-existing more severe portal hypertension). AKI was 50% increase from baseline in preceding 6 months….

				80mg or less per 24hrs).			
Kim SG	2017	Liver transplant	USA	Retrospective – nested case control, on liver transplant waiting list. 205:205 (NSBB 170). 268 ascites, not documented how many refractory. Propranolol/nadolol 81 (median 40mg)/89.	2361	Patients with ascites on a NSBB were more likely to develop AKI during FU than patients with ascites not on a NSBB or patients without ascites. (NSBB with no ascites were less likely to develop AKI on MV analysis??) Lots of problems with this study….	Long study period back to 1990 Primary outcome – development of AKI during median FU of 18 months. Not clear how many were transplanted – and no competing risk analysis NSBB at baseline ie not known if continued during FU. No info given on NSBB vs non NSBB ie differences??
Tergast	2020	AP&T	Germ	Retrospective, patients hospitalised with ascites requiring paracentesis, 45% refractory Prop/carv – n=255 Median dose propranolol (n=147) 30mg/day; carvedilol (n=108) 12.5mg/d.	624	In patients with SBP and MAP<65, NSBB was associated with a rise in serum creat from baseline (not seen in no NSBB arm).	NSBB arm had a lower bil at baseline (and were more likely to have varices). Patients had been acutely admitted to hospital – low MAP will have been representative of acute illness. (30% had AKI) Competing risk Short term FU

Impact of betablockers on reducing development ascites							
Villaneuva C	2004	J Hep	Spain	Prospective long term study of patients receiving nadololol and ISMN as secondary prophylaxis of variceal haemorrhage. Response defined as HVPG<12 or >20% reduction from baseline	132	The probability of developing ascites, HRS or SBP was less in the responders. The haemodynamic response was maintained to 12-18 months in 81%.	Crude stats – minimal adjustment for duration of FU/confounders. Response may reflect earlier in disease spectrum hence less development of complications.
Villaneuva C	2009	Gastroe- terology	Spain	Prospective observational study of response to acute iv propranolol and impact on longer term outcomes	105	Acute haemodynamic response to propranolol (HVPG <12 or >=10% reduction from baseline) associated with reduced variceal bleeding rate during FU and reduced onset of ascites	50% ascites at baseline. 75/105 responders.
Hernandez-Gea	2012	Am J Gastro		Prospective compensated cirrhotics with varices and HVPG>12. Nadolol – 50% haemodynamic responders.	83	Haemodynamic responders had a lower probability of ascites, refractory ascites and HRS during FU.	Trend towards higher CPS and MELD score in non responders. ? non response a surrogate marker of more advanced liver disease.
Villanueva	2019	Lancet	Spain	RCT of NSBB vs not in compensated cirrhosis with HVPG >=10..	201	NSBB associated with reduced primary outcome measure – due to a reduced rate of ascites development.	Short term FU

				101:100. Depending on HVPG response – propranolol or carvedilol. Primary outcome measure – decompensation (development of ascites, bleeding, enceph) or death.			
Turco L	2020	Clin Gastro Hepat	Spain	Metaanalysis of studies of primary/secondary prophylaxis of varices. 5x RCTs and 10 observational.	452	Amongst the 452 patients with ascites, haemodynamic responders had a lower rate of clinical events (variceal haemorrhage, refractory ascites, SBP, HRS or encephalopathy) than non responders	Rate of HVPG responders lower in ascites than non ascites patients ie same concern that non response may reflect more advanced disease.

Supplementary Table 12: Reported survival rates and reversal of hepatorenal syndrome (HRS) in randomised controlled studies involving terlipressin among patients with HRS in cirrhosis. (Reproduced with permission from Palaniyappan, N. and Aithal, G.P. (2020), Editorial: treating hepatorenal syndrome—a window and the views. Aliment Pharmacol Ther, 52: 895-896. doi:10.1111/apt.15943)

		Survival			Reversal of HRS	
		Terlipressin	**Comparator**		**Terlipressin**	**Comparator**
Terlipressin vs placebo	Solanki 2003 (n=24)	42%	0%	*15-day survival*	42%	0%
	Sanyal 2008 (n=112)	43%	38%	*6-month survival*	34%	13%
	Neri 2008 (n=52)	54%	19%	*6-month survival*	81%	19%
	Martín-Llahí 2008 (n=46)	26%	17%	*3-month survival*	35%	11%
	Zafar 2012 (n=50)	24%	20%	*3-month survival*	40%	8%
	Boyer 2016 (n=196)	57%	55%	*3-month survival*	20%	13%
	Wong 2019 (n=300)	27%	29%	*3-month survival*	29%	16%
Terlipressin vs Noradrenaline	Alessandria 2007 (n=22)	67%	70%	*3-month survival*	83%	70%
	Sharma 2008 (n=49)	55%	55%	*30-day survival*	50%	50%
	Singh 2012 (n=46)	30%	35%	*30-day survival*	39%	43%
	Indrabi 2013 (n=60)	7%	3%	*3-month survival*	57%	53%

	Badawy 2013 (n=51)	54%	48%	*30-day survival*	46%	40%
	Ghosh 2013 (n=46)	61%	65%	*3-month survival*	74%	74%
	Goyal 2016 (n=41)	45%	48%	*2-week survival*	50%	48%
	Arora 2020 (n=120)	48%	20%	*28-day survival*	40%	17%
Terlipressin vs Octreotide & Midodrine	Cavallin 2015 (n=49)	59%	43%	*3-month survival*	56%	5%
Terlipressin vs Dopamine & Furosemine	Srivastava 2015 (n=80)	23%	20%	*30-day survival*	*Not reported*	*Not reported*
		Terlipressin Bolus	**Terlipressin Infusion**		**Terlipressin Bolus**	**Terlipressin Infusion**
Terlipressin bolus vs Terlipressin infusion	Cavallin 2016 (n=71)	69%	53%	*3-month survival*	65%	76%