



**Clinical Commissioning Policy:
Use of defibrotide in severe veno-
occlusive disease following stem
cell transplant**

Reference: NHS¹ England B04/P/c

NHS England

Clinical Commissioning Policy: Use of defibrotide in severe veno-occlusive disease following stem cell transplant

First published: January 2015

**Prepared by NHS England Clinical Reference Group for Blood and Marrow
Transplantation**

Published by NHS England, in electronic format only.

NHS England INFORMATION READER BOX**Directorate**

Medical	Commissioning Operations	Patients and Information
Nursing	Trans. & Corp. Ops.	Commissioning Strategy
Finance		

Publications Gateway Reference: 02661

Document Purpose	Policy
Document Name	B04/P/c Clinical Commissioning Policy: Use of defibrotide in severe veno-occlusive disease following stem cell transplant
Author	NHS England
Publication Date	January 2015
Target Audience	CCG Clinical Leaders, CCG Accountable Officers, Foundation Trust CEs , Medical Directors, Directors of PH, Directors of Nursing, NHS England Regional Directors, NHS England Area Directors, Directors of Finance, Communications Leads, NHS Trust CEs
Additional Circulation List	
Description	NHS England will routinely commission defibrotide, a drug used to treat severe veno-occlusive disease (VOD) following Haematopoietic Stem Cell Transplantation (HSCT). Commissioning of defibrotide outside the criteria or for any indication other than treatment of severe VOD is not permitted by this policy. Audit requirements for use are set out.
Cross Reference	n/a
Superseded Docs (if applicable)	n/a
Action Required	n/a
Timing / Deadlines (if applicable)	
Contact Details for further information	NHS England Medical Directorate Skipton House London Road SE1 6LH 0300 311 22 33 http://www.england.nhs.uk/commissioning/spec-services/
Document Status	This is a controlled document. Whilst this document may be printed, the electronic version posted on the intranet is the controlled copy. Any printed copies of this document are not controlled. As a controlled document, this document should not be saved onto local or network drives but should always be accessed from the intranet

Contents

Policy Statement	5
Equality Statement	5
Plain Language Summary	5
1. Introduction	6
2. Definitions	6
3. Aim and objectives	7
4. Epidemiology and needs assessment.....	7
5. Evidence base.....	8
6. Rationale behind the policy statement.....	12
7. Criteria for commissioning	12
8. Patient pathway	13
9. Governance arrangements.....	13
10. Mechanism for funding.....	14
11. Audit requirements	14
12. Documents which have informed this policy.....	14
13. Links to other policies.....	14
14. Date of review	14
References.....	14

Policy Statement

NHS England will routinely commission defibrotide in accordance with the criteria outlined in this document.

In creating this policy NHS England has reviewed this clinical condition and the options for its treatment. It has considered the place of this treatment in current clinical practice, whether scientific research has shown the treatment to be of benefit to patients, (including how any benefit is balanced against possible risks) and whether its use represents the best use of NHS resources.

This policy document outlines the arrangements for funding of this treatment for the population in England.

Equality Statement

Throughout the production of this document, due regard has been given to eliminate discrimination, harassment and victimisation, to advance equality of opportunity, and to foster good relations between people who share a relevant protected characteristic (as cited in under the Equality Act 2010) and those who do not share it.

Plain Language Summary

Severe veno-occlusive (VOD) disease of the liver is a rare complication of stem cell transplantation caused by the chemotherapy and / or radiotherapy that patients receive as part of preparation for transplant. It is most likely to affect patients with certain risk factors or underlying conditions. Severe VOD is associated with a high risk of death and can cause multi-organ failure requiring long stays in hospital, often in Intensive Care. A drug called defibrotide can be given to adults or children with severe VOD to treat the condition.

1. Introduction

Veno-occlusive disease of the liver (VOD) occurs as a result of the conditioning treatment administered prior to haemopoietic stem cell transplantation, otherwise known as BMT. The condition is also known as sinusoidal obstruction syndrome in view of the associated characteristic histopathological findings (De Leve et al, 1999). The terms veno-occlusive disease and sinusoidal obstruction syndrome are used interchangeably in this document.

The mean prevalence of VOD is in the range of 14% (range 0-60%) depending upon the risk factors present (Coppell et al, 2010). The condition causes considerable morbidity and mortality and severe VOD is associated with a mortality of over 80% by day + 100 following HSCT (McDonald et al, 1993; Carreras et al, 1998).

Defibrotide is supplied by Jazz Pharmaceuticals who acquired the original manufacturing company, Gentium.

Defibrotide is indicated for the treatment of sVOD in HSCT:

- It is indicated in adults and in adolescents, children and infants over 1 month of age.
- Defibrotide was granted Orphan Drug Status by the EMA in 2004 and has been supplied in the UK and in more than 40 countries on a named patient basis since 2009.
- Defibrotide is a Hospital only product due to the specialised nature of this disease and mode of delivery of the prescription medicine.
- The use of defibrotide does not change the pathway of care, therefore the only changes to the budget are drug acquisition costs and cost avoidance as a result of reduced ICU/HDU use.
- Defibrotide has been granted a license by the EMA for the treatment of severe hepatic VOD in adults & children.

2. Definitions

Conditioning – this is term used to describe the preparative regimen of chemotherapy and / or radiotherapy that patients receive prior to stem cell transplant.

Autologous stem cell transplant – this is the process of high dose chemotherapy followed by infusion of the patient's own stem cells which will repopulate the bone marrow and allow the recovery of the patient's blood counts.

Allogeneic stem cell transplant – this is the process of high dose chemotherapy followed by infusion of donor stem cells.

3. Aim and objectives

This policy aims to:

- Identify the adult and paediatric patients that are suitable for use of defibrotide for the treatment of severe veno-occlusive disease.

The objectives are to:

- To enable patients who develop severe veno-occlusive disease to access treatment to reduce morbidity and mortality from this condition.

4. Epidemiology and needs assessment

The mean prevalence of VOD is in the range of 14% (range 0-60%) depending upon the risk factors present (Coppell *et al*, 2010).

According to the British Society for Blood and Marrow Transplantation (BSBMT) registry, 1440 allogeneic stem cell transplants were undertaken in 2011, of which 280 were in paediatric patients. Of these, 877 patients had reduced intensity or “mini” allografts and would be unlikely to develop VOD. Assuming that 14% of the remaining 563 patients developed VOD, an estimated 78 patients per year in the UK would require treatment with defibrotide, which is in line with data provided on usage in 2013 (71 patients).

<http://bsbmt.org/2011-activity/> (accessed 28/6/2013)

Defibrotide has also been used in high risk paediatric patients to prevent VOD although this indication is not licenced. Data on usages in 2013 indicated c.64 patients were treated with prophylaxis.

Table 1: Historical defibrotide Usage in Named Patient Program

Number of Patients	2010	2011	2012	2013
Treatment of sVOD	68	86	64	71
Prevention	42	61	83	64
Unknown/Other	8	14	10	17
Total Patients	118	161	157	152

Source: Jazz Pharmaceutical

Alternative treatment strategies

There is no standard alternative treatment strategy for severe VOD. Agents such as N-acetylcysteine and tissue plasminogen activators have been investigated but have not been found to be beneficial. High dose methylprednisolone may be helpful in some patients. The mainstay of supportive care in patients with VOD is management of fluid balance. Renal replacement therapy may be required in severe cases. Patients with multi-organ failure will require management in a high-

dependency or intensive care environment. Early discussion with a specialist hepatology unit is advised regarding further therapeutic options.

Prostaglandin E1, pentoxifylline and heparin (unfractionated and low molecular weight) have been investigated for use in the prophylaxis of VOD and have not been found to be helpful. Ursodeoxycholic acid may be used either alone or in combination with defibrotide in the prophylaxis of VOD.

5. Evidence base

Defibrotide is a single-stranded polydeoxyribonucleotide which has anti-thrombotic, anti-inflammatory and anti-ischaemic properties. This agent appears to have a protective effect against endothelial cell injury by cytotoxic agents and down regulates protein concentrations, gene expression and the activity of endothelial cell triggers such as heparanase (Eissner *et al*, 2002). Defibrotide has not been associated with an increased bleeding risk despite reducing pro-coagulant activity and increasing fibrinolysis (Echart *et al*, 2009; Falanga *et al*, 2003). Following reports of the success of defibrotide in the treatment of VOD, several studies have focused on the role of this agent in prophylaxis.

According to guidelines published by the British Committee for Standards in Haematology and the British Society for Blood and Marrow Transplantation, the quality of evidence to support a recommendation of use of defibrotide in treatment of veno-occlusive disease (sinusoidal obstruction syndrome) in adults and children is 1B.

Several studies in both adults and children have reported on the efficacy of defibrotide in the treatment of veno-occlusive disease. Richardson *et al* reported on 19 patients who had received defibrotide for the management of severe veno-occlusive disease in a compassionate use study (Richardson *et al*, 1998). Intravenous defibrotide was administered in doses ranging from 5 mg/kg per day to 60 mg/kg per day. Patients were included if they had a clinical diagnosis of VOD (bilirubin > 34.2 µmol/L and two of the following: hepatomegaly and/or right upper quadrant pain, ascites or greater than 5% weight gain above admission weight) or a positive biopsy result. In addition, patients who presented within 16 days of transplant had a predicted risk score of 40% defined by the Bearman model or, if presenting after day + 16, VOD constituted their main clinical problem. Eight patients (42%) had resolution of VOD as defined by resolution of bilirubin to < 34.2 µmol/L and improvement of other symptoms and signs of VOD.

An additional 69 patients received defibrotide on an emergency use basis based on the emergent data. Patients were enrolled prospectively from 8 transplantation centres and received a dose ranging from 5 to 60 mg/kg/day. Patients were included based on a clinical diagnosis (bilirubin ≥ 34.2 µmol/L, hepatomegaly and/or right upper quadrant pain, and ≥ 5% weight gain from admission, with or without ascites) or two clinical criteria and positive hepatic biopsy. Patients had to have a predicted risk score of 30% as defined by the Bearman model or, if presenting after day +16, VOD was considered their main clinical problem and organ failure was present in at least one organ system. Complete response was defined as in the pilot study. The complete response rate in 88 patients (including the 19 patients in the pilot study) was 36% and survival at day +100 was 35% (Richardson *et al*, 2002).

A randomised phase II dose-finding study was subsequently conducted by the same group. Adult or paediatric patients were included if they had a clinical diagnosis of VOD by day +35 post-HSCT or biopsy proven VOD. Patients were also included if they had portal vein flow reversal on ultrasound, jaundice and one other clinical criterion. Patient eligibility was also defined by the severity criteria from the previous study (Richardson *et al*, 2002). Patients were randomised to receive lower dose defibrotide (25 mg/kg/day, n = 75) or higher dose defibrotide (40 mg/kg/day, n = 74) administered intravenously every 6 hours for \geq 14 days or until complete response, progression of VOD or unacceptable toxicity was observed (Richardson *et al*, 2010). Complete response was defined as total serum bilirubin $<$ 34.2 μ mol/L with resolution of VOD-related multi-organ failure. The overall complete response rate was 46% and there was no significant difference between the two arms. The day +100 post HSCT survival rates were 42% and again there was no significant difference between the two arms. There was a slightly higher rate of adverse events in the higher dose arm (10% v 7%) but this difference did not achieve statistical significance.

The lower dose of defibrotide was subsequently selected for phase III trials in VOD as there was no difference in efficacy or toxicity in the phase II randomised study. The results of a phase III study comparing the use of defibrotide in the treatment of severe VOD to an historical control group have been presented in abstract form (Richardson *et al*, 2009). Patients were included if they met the Baltimore criteria for VOD and complete response was assessed as bilirubin $<$ 34.2 μ mol/L and resolution of multi-organ failure. One hundred and two patients received defibrotide intravenously at a dose of 6.25 mg/kg four times daily and were compared to 32 historical control patients. The day + 100 complete response rate was 24% in the treatment arm compared to 9% in the historical control group ($p=0.015$). The day + 100 mortality rate was 62% in the treatment arm compared to 75% in the control group ($p=0.051$). Haemorrhagic adverse events were similar in the two groups.

Following completion of the above trial, the protocol was continued and patients were included if they met the eligibility for the trial or if they had non-severe VOD or had developed VOD after chemotherapy rather than after haematopoietic stem cell transplantation. The results of this expanded access programme have been reported in abstract form (Richardson *et al*, 2011, Richardson *et al*, 2012). The latest interim analysis reported on 333 patients (305 who had undergone HSCT with 274 undergoing an allogeneic transplant). Two hundred and twenty patients had severe disease at study entry. The overall complete response rate was 30% with a 50% survival rate at day + 100 in HSCT patients. In the patients with non-severe VOD the CR rate was 39% and the day + 100 survival rate was 65%. The 155 patients who met the original trial criteria had a complete response rate of 29% compared to 9% in the historical control group ($p=0.0019$) and superior survival at day + 100 (49% versus 25%, $p=0.0016$). The main toxicities were haemorrhage in 18% and hypotension in 4% of patients with 2% of patients experiencing life-threatening haemorrhage. (Richardson *et al*, 2012)

The role of defibrotide in the treatment of VOD has also been investigated by other groups. Corbacioglu *et al* reported a retrospective analysis of 45 patients aged between 0.2 and 20 years who received defibrotide intravenously at an average dose of 40 mg/kg/day. VOD was diagnosed using the Baltimore criteria. Complete response was defined as resolution of VOD and multi-organ failure-related

symptoms and a bilirubin of < 34.2 µmol/L. Twenty-two patients had severe disease and 23 had moderate or mild disease. The overall complete response (CR) rate was 76% with a survival rate of 64% at day + 100 (Corbacioglu *et al*, 2004). Bulley *et al* have also reported a retrospective series of the use of defibrotide in paediatric patients. In this series of 14 patients, 60% stopped defibrotide due to clinical improvement and the survival rate to day + 100 was 79% (Bulley *et al*, 2007). The European compassionate-use study included 40 patients who fulfilled either the Baltimore or Seattle criteria for VOD and received intravenous defibrotide (10 to 40 mg/kg daily). Twenty-two patients (55%) showed a complete response as defined by bilirubin < 34.2µmol/l and resolution of signs/symptoms of VOD and end-organ dysfunction. The survival rate at day + 100 was 43%. The complete response rate in the 10 poor-risk patients was 36% (Chopra *et al*, 2000).

Use of defibrotide in preventing VOD

Whilst there is randomized control data supporting use of defibrotide in prevention of VOD in a small group of children undergoing allogeneic stem cell transplantation with high risk factors, this use is not licensed. Data also suggest that use in prevention may not represent a cost effective treatment.

COST-EFFECTIVENESS

Haematopoietic stem cell transplant is a cost-effective but expensive therapy for many haematological malignancies. A large proportion of the costs are associated with the high cost of the length of the initial hospital stay and subsequent readmissions. Post-transplant complications, e.g VOD or graft-versus-host disease are major risk factors associated with high costs (Svahn *et al*, 2012).

Treatment

VOD is a potentially life-threatening post-HSCT complication that is reported to be severe in approximately 33% of cases (Carreras *et al*, 2011). Severe VOD can be fatal in more than 80% of cases (Coppell *et al*, 2010). Severe VOD is frequently associated with multi-organ failure and the necessity for prolonged hospital admission including the need for intensive care support.

Post-HSCT complications are a significant contributor to the costs of HSCT. VOD has been shown to be one of the most costly complications (Svehlen 2006)² post-transplant. Five-year post-transplant, VOD patients cost 63% more compared with patients that didn't develop VOD. After one-year post HSCT, the cost for patients with VOD is nearly double that of patients that don't develop VOD. Most of this excess cost is incurred within the inpatient setting shortly after transplant.

Without treatment patients with severe VOD may die within days or weeks of an expensive transplant procedure, often in an intensive care setting. Defibrotide has been shown to be effective in the treatment of severe VOD in several studies, with complete response rates of 24% to 49%, and with a significant improvement in survival of 52% at day 100.

There is no published QALY data for the UK but the consideration of cost utility for

treatment of severe VOD are set out in the Scottish Medicines Consortium advice (May 2014). The acquisition costs of defibrotide list price are affected by the factors set out in Table 2. The price of defibrotide is based on the expected list price. Paediatric patients will cost less than adult patients based on weight and dosing.

Table 2: Factors affecting average cost per course of treatment with defibrotide

Parameter	Value
Average body weight at baseline (kg)	53.70
Average daily dose (mg/kg/day) of defibrotide	16.42
Length of defibrotide treatment (mean, in days)	23.30
Costs per 200mg vial (expected list price)	£365.00
Mg per vial	200.00
Wastage (maximum number of vials wasted)	0.5

Source: Jazz Pharmaceuticals

Defibrotide treatment needs to be compared with costs of severe VOD which are based on extended lengths of stay. This is set out in table 3 using data from studies to calculate differences in length of stay between patients treated with defibrotide and those in an historical control arm who did not receive defibrotide. A weighted average bed day price is used based on 12/13 NHS Reference Costs. The impact assessment is set out in table 4.

Table 3: Hospital Bed Days Saved

LOS (in days)	Defibrotide arm	Historical Control arm
Mean time from transplant to complete remission	46.30	62.00
Average LOS in hospital for transplant (ICU/HDU)	17.82	17.82
“Excess” hospital stay due to severe VOD	28.48	44.18
Difference between arms (bed saving days)	-15.70	
Costs (£)	Defibrotide arm	Historical Control arm
Cost per additional bed day in hospital	£1,879.80	£1,879.80

Total "excess" hospital cost	£53,537	£83,050
Difference between arms	-£29,513	

Source: Jazz Pharmaceuticals

Table 4: Incremental Budget Impact

Drug Acquisition Cost	£33,796 per patient
Cost Offset Reduced ICU/HDU LOS	-£29,513 per patient
Incremental Cost per patient	£4,283

Source: Jazz Pharmaceuticals

In summary, treatment with defibrotide reduces mortality compared with historical controls. Defibrotide reduces the length of stay avoiding extended use of ICU or HDU beds.

Safety

Defibrotide is well tolerated with few adverse events. An increased risk of haemorrhage has not been associated with use of this agent.

6. Rationale behind the policy statement

Severe VOD is a condition with a high rate of morbidity and mortality. It is rare in the majority of patients undergoing allogeneic transplantation but several high risk groups have been identified. The evidence from a phase III randomised controlled trial suggests that the use of defibrotide is effective in preventing VOD in selected high risk groups and the data from phase III prospective studies in the treatment of VOD also suggest the efficacy of defibrotide in the treatment of the disorder. Defibrotide is well tolerated with minimal toxicity. This policy therefore recommends defibrotide for the treatment of severe VOD when it occurs following stem cell transplantation.

7. Criteria for commissioning

Patient selection

Patients eligible to receive treatment with defibrotide would include:

- Adults or children who have a diagnosis of severe veno-occlusive disease following BMT based on clinical criteria (modified Seattle or Baltimore criteria) or histopathological findings:

Modified Seattle Criteria	Baltimore Criteria
Two of the following criteria must be present within 20 days of transplant:	Bilirubin must be > 34.2 µmol/l (2mg/dL) within 21 days of transplant and two of the following criteria must be present
Bilirubin > 34.2 µmol/l (2mg/dL)	Hepatomegaly
Hepatomegaly or right upper quadrant pain	Ascites
Weight gain (> 2% from pre-transplant weight)	Weight gain (> 5% from pre-transplant weight)

Starting Criteria

- Patients requiring **treatment** would receive 6.25 mg/kg of defibrotide intravenously four times daily from the onset of clinical signs of veno-occlusive disease.

Stopping Criteria

- Defitelio should be administered for a minimum of 21 days and continued until the symptoms and signs of severe VOD resolve.

Exclusions

Defibrotide will **not be routinely commissioned** in the following scenarios:

- In patients with active bleeding
- Prevention of VOD in either paediatric or adult patients
- For treatment of graft versus host disease.

Where clinicians consider prescribing defibrotide for patients not covered in the circumstances above, an Individual Funding Request may be considered where the patient's case is exceptional.

8. Patient pathway

Patients for haematopoietic stem cell transplantation will normally be referred to a transplant centre as per the local referral policy. The transplant team will be responsible for the authorisation and administration of defibrotide for patients requiring this intervention. There will be no change to existing arrangements following approval of this policy

9. Governance arrangements

- Consent, patient evaluation and investigations prior to the commencement of defibrotide must be carried out by the transplant centre in accordance with relevant transplant centre policy.
- No additional investigations are required for the provision of defibrotide. All processes involved in haematopoietic stem cell transplantation must fulfil Human Tissue Authority (HTA) requirements and must meet JACIE standards in line with accreditation standards.
- All centres should have a local standard operating procedure detailing the

use of defibrotide.

10. Mechanism for funding

NHS England is responsible for funding defibrotide in line with this policy as part of and consistent with existing, agreed local contract currencies.

11. Audit requirements

Regular audit should be carried out on the use of defibrotide. Audit criteria will encompass the following:

- The % of patients undergoing allogeneic transplantation who receive defibrotide treatment and outcomes.
- Patients receiving defibrotide to demonstrate compliance with commissioning criteria.

12. Documents which have informed this policy

BCSH/BSBMT Guideline: Diagnosis and Management of Veno-occlusive Disease (Sinusoidal Obstruction Syndrome) following Haematopoietic Stem Cell Transplantation (submitted to British Journal of Haematology)

13. Links to other policies

This policy follows the principles set out in the ethical framework that govern the commissioning of NHS healthcare and those policies dealing with the approach to experimental treatments and processes for the management of individual funding requests (IFR).

14. Date of review

This policy will be reviewed in April 2016 unless information is received which indicates that the proposed review date should be brought forward or delayed.

References

Bulley [SR](#), [Strahm B](#), [Doyle J](#), [Dupuis LL](#). Defibrotide for the treatment of hepatic veno-occlusive disease in children. [Pediatr Blood Cancer](#). 2007 Jun 15;48(7):700-4.

Cappelli B, Chiesa R, Evangelio C, Biffi A, Rocchia T, Frugnoli I, Biral E, Noè A, Fossati M, Finizio V, Miniero R, Napolitano S, Ferrua F, Soliman C, Ciceri F, Roncarolo MG, Markt S. [Absence of VOD in paediatric thalassaemic HSCT recipients using defibrotide prophylaxis and intravenous Busulfan](#). [Br J Haematol](#). 2009 Nov;147(4):554-60.

Carreras [E](#), [Bertz H](#), [Arcese W](#), [Vernant JP](#), [Tomás JF](#), [Hagglund H](#), [Bandini G](#), [Esperou H](#), [Russell J](#), [de la Rubia J](#), [Di Girolamo G](#), [Demuyneck H](#), [Hartmann O](#), [Clausen J](#), [Ruutu T](#), [Leblond V](#), [Iriando A](#), [Bosi A](#), [Ben-Bassat I](#), [Koza V](#), [Gratwohl A](#), [Apperley JF](#). Incidence and outcome of hepatic veno-occlusive disease after blood or marrow transplantation: a prospective cohort study of the European Group for Blood and Marrow Transplantation. [European Group for Blood and Marrow](#)

Transplantation Chronic Leukemia Working Party. Blood. 1998 Nov 15;92(10):3599-604.

Chalandon Y, Roosnek E, Mermillod B, Newton A, Ozsahin H, Wacker P, Helg C, Chapuis B. Prevention of veno-occlusive disease with defibrotide after allogeneic stem cell transplantation. Biol Blood Marrow Transplant. 2004 May;10(5):347-54.

Chopra R, Eaton JD, Grassi A, Potter M, Shaw B, Salat C, Neumeister P, Finazzi G, Iacobelli M, Bowyer K, Prentice HG, Barbui T. Defibrotide for the treatment of hepatic veno-occlusive disease: results of the European compassionate-use study. Br J Haematol. 2000 Dec;111(4):1122-9.

Coppell JA, Richardson PG, Soiffer R, Martin PL, Kernan NA, Chen A, Guinan E, Vogelsang G, Krishnan A, Giralt S, Revta C, Carreau NA, Iacobelli M, Carreras E, Ruutu T, Barbui T, Antin JH, Niederwieser D. Hepatic veno-occlusive disease following stem cell transplantation: incidence, clinical course, and outcome. Biol Blood Marrow Transplant. 2010 Feb;16(2):157-68.

Corbacioglu S, Greil J, Peters C, Wulffraat N, Laws HJ, Dilloo D, Straham B, Gross-Wieltsch U, Sykora KW, Ridolfi-Lüthy A, Basu O, Gruhn B, Güngör T, Mihatsch W, Schulz AS. Defibrotide in the treatment of children with veno-occlusive disease (VOD): a retrospective multicentre study demonstrates therapeutic efficacy upon early intervention.

Bone Marrow Transplant. 2004 Jan;33(2):189-95.

Corbacioglu S, Hönig M, Lahr G, Stöhr S, Berry G, Friedrich W, Schulz AS. Stem cell transplantation in children with infantile osteopetrosis is associated with a high incidence of VOD, which could be prevented with defibrotide. Bone Marrow Transplant. 2006 Oct;38(8):547-53.

Corbacioglu S, Cesaro S, Faraci M, Valteau-Couanet D, Gruhn B, Rovelli A, Boelens JJ, Hewitt A, Schrum J, Schulz AS, Müller I, Stein J, Wynn R, Greil J, Sykora KW, Matthes-Martin S, Führer M, O'Meara A, Toporski J, Sedlacek P, Schlegel PG, Ehlert K, Fasth A, Winiarski J, Arvidson J, Mauz-Körholz C, Ozsahin H, Schrauder A, Bader P, Massaro J, D'Agostino R, Hoyle M, Iacobelli M, Debatin KM, Peters C, Dini G. Defibrotide for prophylaxis of hepatic veno-occlusive disease in paediatric haemopoietic stem-cell transplantation: an open-label, phase 3, randomised controlled trial. Lancet. 2012 Apr 7;379(9823):1301-9.

DeLeve LD, McCuskey RS, Wang X, Hu L, McCuskey MK, Epstein RB, Kanel GC. Characterization of a reproducible rat model of hepatic veno-occlusive disease. Hepatology. 1999 Jun;29(6):1779-91.

Dignan F, Gujral D, Ethell M, Evans S, Treleaven J, Morgan G, Potter M. Prophylactic defibrotide in allogeneic stem cell transplantation: minimal morbidity and zero mortality from veno-occlusive disease. Bone Marrow Transplant. 2007 Jul;40(1):79-82.

Echart CL, Graziadio B, Somaini S, Ferro LI, Richardson PG, Fareed J, Iacobelli M. The fibrinolytic mechanism of defibrotide: effect of defibrotide on plasmin activity. Blood Coagul Fibrinolysis. 2009 Dec;20(8):627-34.

Eissner G, Multhoff G, Gerbitz A, Kirchner S, Bauer S, Haffner S, Sondermann D, Andreesen R, Holler E. Fludarabine induces apoptosis, activation, and allogenicity in human endothelial and epithelial cells: protective effect of defibrotide. Blood. 2002 Jul 1;100(1):334-40.

Falanga A, Vignoli A, Marchetti M, Barbui T. Defibrotide reduces procoagulant activity and increases fibrinolytic properties of endothelial cells. Leukemia. 2003 Aug;17(8):1636-42.

McDonald GB, Hinds MS, Fisher LD, Schoch HG, Wolford JL, Banaji M, Hardin BJ, Shulman HM, Clift RA. Veno-occlusive disease of the liver and multiorgan failure after bone marrow transplantation: a cohort study of 355 patients. Ann Intern Med. 1993 Feb 15;118(4):255-67.

Richardson PG, Elias AD, Krishnan A, Wheeler C, Nath R, Hoppensteadt D, Kinchla NM, Neuberger D, Waller EK, Antin JH, Soiffer R, Vredenburgh J, Lill M, Woolfrey AE, Bearman SI, Iacobelli M, Fareed J, Guinan EC. Treatment of severe veno-occlusive disease with defibrotide: compassionate use results in response without significant toxicity in a high-risk population. Blood. 1998 Aug 1;92(3):737-44.

Richardson PG, Murakami C, Jin Z, Warren D, Momtaz P, Hoppensteadt D, Elias AD, Antin JH, Soiffer R, Spitzer T, Avigan D, Bearman SI, Martin PL, Kurtzberg J, Vredenburgh J, Chen AR, Arai S, Vogelsang G, McDonald GB, Guinan EC. Multi-institutional use of defibrotide in 88 patients after stem cell transplantation with severe veno-occlusive disease and multisystem organ failure: response without significant toxicity in a high-risk population and factors predictive of outcome. Blood. 2002 Dec 15;100(13):4337-43.

Richardson P, Tomblyn M, Kernan N, Brochstein J, Mineishi S, Termuhlen A, Arai S, Grupp S, Guinan E, Martin PL, Corbacioglu S, Holler E, D'Agostino R, Massaro J, Hannah A, Iacobelli M, and Soiffer RJ. Defibrotide (DF) in the Treatment of Severe Hepatic Veno-Occlusive Disease (VOD) with Multi-Organ Failure (MOF) Following Stem Cell Transplantation (SCT): Results of a Phase 3 Study Utilizing a Historical Control. Blood (ASH Annual Meeting Abstracts), Nov 2009; 114: 654.

Richardson PG, Soiffer RJ, Antin JH, Uno H, Jin Z, Kurtzberg J, Martin PL, Steinbach G, Murray KF, Vogelsang GB, Chen AR, Krishnan A, Kernan NA, Avigan DE, Spitzer TR, Shulman HM, Di Salvo DN, Revta C, Warren D, Momtaz P, Bradwin G, Wei LJ, Iacobelli M, McDonald GB, Guinan EC. Defibrotide for the treatment of severe hepatic veno-occlusive disease and multiorgan failure after stem cell transplantation: a multicenter, randomized, dose-finding trial. Biol Blood Marrow Transplant. 2010 Jul;16(7):1005-17.

Richardson PG, Smith AR, Grupp SA, Kernan NA, Arai S, Haut PR, Triplett BM, Gillio AP, III, Symons HJ, Adams RH, Horn BN, Lucas K, Martin PL, Mineishi S, Ball ED, Boyer M, Fort J, Kirov II, Lehmann LE, Madigan C, Maglio ME, Massaro J,

D'Agostino RB, Hannah AL, Tudone E, Hume R, Iacobelli M, Soiffer RJ, and Defibrotide Study Group
Defibrotide (DF) in the Treatment of Hepatic Venous Occlusive Disease (VOD) in Stem Cell Transplant (SCT) and Non-SCT Patients (Pts): Early Intervention Improves Outcome - Updated Results of a Treatment IND Expanded Access Protocol Blood (ASH Annual Meeting Abstracts), Nov 2011; 118: 487.

Richardson PG, Smith AR, Kernan NA, Grupp SA, Arai S, Triplett BM, Haut PR, Chan K, Symons HJ, Horn BN, Gillio AP, Boyer M, Krishnan A, Lehmann LE, Martin PL, Mineishi S, Shore TB, Simms-Waldrip T, Antin JH, Hannah AL, Hume R, Tudone E, Heringa C, Soiffer RJ and Defibrotide Study Group Results of a Large Prospective Study On the Use of Defibrotide (DF) in the Treatment of Hepatic Venous Occlusive Disease (VOD) in Hematopoietic Stem Cell Transplant (HSCT). Early Intervention Improves Outcome – Updated Results of a Treatment IND (T-IND) Expanded Access Protocol Blood (ASH Annual Meeting Abstracts), Dec 2012 (abstract 738)

Svahn BM, Remberger M, Alvin O, Karlsson H, Ringdén O. Increased costs after allogeneic haematopoietic SCT are associated with major complications and re-transplantation. Bone Marrow Transplant. 2012 May;47(5):706-15.

http://www.scottishmedicines.org.uk/files/advice/M_Scottish_Medicine_Consortium_Web_Data_Audit_advice_Advice_by_Year_2014_No.6_-_June_2014_defibrotide_Defitelio_FINAL_May_2014_for_website.pdf (accessed 15/06/14)