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Clinical effectiveness of MARS treatment – multidirectional analysis of positive clinical response to treatment

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Abstract

Aim of the study: Liver failure is a life-threatening condition which often requires intensive care treatment. It is essential to quickly determine whether there are indications for extracorporeal liver support systems for the patient. The aims of the study were: to assess effectiveness of molecular adsorbent recirculating system (MARS) therapy based on selected clinical criteria, to analyze the moment of clinical response and to create a patient's profile, who will benefit clinically from the treatment.

Material and methods: The analysis encompassed medical histories of 65 patients treated with MARS. Effectiveness of treatment was evaluated based on selected clinical parameters. Statistical analysis was performed based on medical data gathered.

Results: There were 158 cycles of MARS performed, with effectiveness documented in 57 cycles (36.6%). The first MARS session was effective in 43.1% of patients. They also more often responded to the second cycle (63.6% vs. 15.4%). A significant part of the analysis was devoted to create a profile of the patient in whom positive response can be expected. A low MELD score and low baseline white blood cells (WBC) level are statistically significant factors in multivariate analysis of selected features of positive clinical response to treatment.

Conclusions: MARS therapy is an effective form of treatment in a properly selected group of patients with liver failure. The first MARS session is the most effective one. It is also a good prognostic factor for further clinical response to treatment. Multifactorial analysis of positive clinical response to treatment enables to create a patient's profile based on the lower baseline MELD score and WBC.

Key words: liver failure, MARS therapy, liver support system, albumin dialysis.

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Introduction

Molecular adsorbent recirculating system (MARS) is the most frequently used nonbiological system for supporting the failing liver. The concept behind MARS is based on the process of dialysis, filtration and adsorption helping in spontaneous liver regeneration or bridging to liver transplantation [1, 2].

Identifying patients who survive without liver transplantation is important but very difficult. Clinical prognostic factors are very unreliable. Currently, acute liver failure etiology is considered the most important prognostic factor. The survival rate of ≥ 50% without liver transplantation happens in cases of paracetamol poisoning, acute hepatitis type A, liver ischemia and pregnancy-induced liver failure. In other etiologies the survival rate without liver transplantation is less than 25%. Coexisting kidney failure and high-grade encephalopathy also reduce the chances of spontaneous liver regeneration [3, 4]. Many prognostic models have

been created with the goal of proper patient selection for liver transplantation. Most of the models were faulty and biased [3, 5].

The most frequently used scale in patients with chronic liver failure is the Child-Pugh score [6] and in acute liver failure (ALF) King's College criteria [3, 7] or Clichy's criteria [3, 8]. Prognostic factors determining survival in liver failure are constantly evaluated, but it seems that scales limited to liver function are less reliable compared to multiorgan assessment scales such as SOFA [9, 10] or APACHE [9, 11]. MARS therapy did not contribute to mortality reduction in ALF or acute-on-chronic liver failure (ACLF) [12].

This raises the question of how we can determine the effectiveness of albumin dialysis in liver failure.

The literature describes two groups of such parameters: clinical and laboratory. Among clinical parameters, the most important ones include encephalopathy reduction [12, 13], improvement in kidney function in hepato-renal syndrome [14], pruritus reduction in hyperbilirubinemia [15, 16] and improvement in hemodynamic parameters [17]. The other group of parameters determining the effectiveness of MARS treatment encompasses biochemical parameters. MARS therapy is a very effective method of removal of toxins and many other noxious substances [18]. Due to the variability of MARS assessment in the context of effectiveness, it seems prudent to ask what parameters are truly helpful and whether it is possible to create a profile of patients who benefit from the treatment.

The aims of this study were to assess the effectiveness of MARS therapy based on selected clinical criteria, analyze the moment of clinical response and attempt to create a profile of patients who will benefit clinically from the treatment.

Material and methods

All MARS sessions performed in patients between 2007 (introduction of MARS in our department) and 2015 were analyzed. The following data were collected: demographics, diagnosis and etiology of liver disease, MELD [19] and SAPS II [20] scores and laboratory results. Blood tests were routinely taken just before each MARS session and within one hour of albumin dialysis completion.

Written informed consent was obtained from the patient. In lifethreatening situations consent was not obtained. The protocol was approved by the institution's local ethics committee (Dolnoslaska Izba Lekarska, approval number 3/DR/2016).

Liver failure was diagnosed using the following definitions:

1. Acute liver failure was diagnosed in patients without previously known liver disease and with acute deterioration of liver function, shown as elevation of the international normalized ratio (INR) > 1.5 and encephalopathy [3].
2. Acute-on-chronic liver failure was considered in patients with acute deterioration of previously existing chronic liver disease, usually related to a precipitating event and associated with increased mortality at 3 months due to multi-system organ failure [9].
3. Acute decompensation (AD) was defined by the acute development of one or more major complications of liver disease (i.e. ascites, encephalopathy, esophageal varices hemorrhage or infection) without organ dysfunction [21].

Eligibility for MARS treatment

Patients with ALF, ACLF and AD were screened for eligibility for MARS therapy after ineffective symptomatic treatment of a liver disease or triggering factor of liver decompensation. MARS was recommended provided that the liver disease or triggering factor was treatable or if the patient was qualified for liver transplantation. Uncontrolled systemic infection was regarded as a contraindication for MARS treatment [22].

Performance of MARS therapy

MARS therapy was performed using combined MARS and Prismaflex sets manufactured by GAMBRO AB LUND. The right internal jugular vein was the venous access of choice for the MARS procedure. To increase the safety of venous access in patients with abnormal coagulation we used ultrasound guidance. Dialysis was performed in continuous veno-venous hemodiafiltration (CVVHDF). During therapy two types of anticoagulation were used: systemic anticoagulation with heparin using the dedicated syringe in the Prismaflex circuit, and regional anticoagulation with citrate infused by pre-blood pump (PBP), and calcium chloride substituted through a separate syringe. In a few patients MARS therapy was conducted without anticoagulation. Such a solution was used in patients with high risk of bleeding or signs of active bleeding. Flow rates during MARS treatment were chosen according to the anticoagulation used (Table 1) [22].

Safety and tolerability of MARS treatment

Safety and tolerability of MARS treatment were mainly focused on the potential complications of anticoagulation used.

Table 1. Flow rates during MARS treatment according to anticoagulation used

	Systemic anticoagulation with heparin	Regional anticoagulation with citrate	Without anticoagulation
Albumin flow	100-150 ml/min	100-150 ml/min	100-150 ml/min
Blood flow in Prismaflex circuit	100-150 ml/min	100-120 ml/min	100-150 ml/min
Pre-blood pump (PBP) flow	100-250 ml/h	1000-1200 ml/h	500-1000 ml/h
Dialysate flow	500-1000 ml/h	500-1000 ml/h	500-1000 ml/h
Substitute flow	500-1000 ml/h	100-250 ml/h	100-500 ml/h
CVVHDF treatment dose	> 20 ml/kg/h	> 20 ml/kg/h	> 20 ml/kg/h

Systemic anticoagulation was monitored with activated clotting time (ACT) or activated partial thromboplastin time (APTT) taken every 2-4 hours during treatment.

Safety of regional anticoagulation was monitored in the following way:
- calcium citrate accumulation using Ca/Ca^{2+} ratio taken every 4 hours; a ratio < 2.5 was considered safe;
- acid-base balance analysis;
- electrolyte derangements analysis;
- clinical assessment based on looking for signs of bleeding or necessity to transfuse blood products.

Effectiveness assessment

Analyzing the effectiveness of MARS treatment, we focused mainly on clinical improvement. We analyzed: encephalopathy reduction using West Haven Criteria [23], improvement in diuresis in hepato-renal syndrome, and pruritus reduction based on subjective assessment by patients. We did not analyze the hemodynamic profile due to the lack of hemodynamic monitoring in many patients. We considered therapy as effective when one of the above-mentioned parameters improved after treatment: improvement of encephalopathy of one grade, improvement of diuresis > 500 ml/24 h or pruritus reduction determined by the patient.

Statistical analysis

Analysis of differences in the level of quantitative parameters, depending on the response to treatment, was performed by means of the Mann-Whitney test, and in the case of qualitative parameters by means of Fisher's exact test. Analysis of significant changes in laboratory parameters in the course of MARS treatment was performed by means of the Wilcoxon test for paired data. Multifactorial analysis of the influence of parameters for the probability of a positive response to treatment was performed by means of regression analysis. Statistical analysis was performed using the

R statistical package for Windows (version 3.2.2) and diagrams were created using the ggplot2 library [24].

Results

Between 2007 and 2015, there were 65 patients qualified for MARS therapy included in the analysis. Thirteen (20%) patients had an ALF, 34 (52.3%) had an ACLF and 18 (23.1%) had acute decompensation of liver function (AD). Etiological factors included: active or chronic viral infection – 10 (15.4%) patients, autoimmune liver and biliary disease – 13 (20%) patients, toxic liver impairment due to alcohol, xenobiotics and medications, other rare diseases or unknown factor – 12 (18.5%) patients (Table 2).

In the analyzed group, 158 MARS sessions were performed, lasting 1.3 h to 20.5 h (median 10.2 h). MARS therapy was planned for 10-12 h, and longer sessions played the role of continuous renal replacement therapy (CRRT) in some of the patients. Every patient had one to seven MARS sessions (median – 2 sessions). MARS therapy was well tolerated. We noted only 13 episodes of bleeding: 2 episodes of bronchial bleeding, 5 episodes of variceal bleeding, and 6 episodes of catheter bleeding. In addition to bleeding complications only one patient in the citrate group had a Ca/Ca^{2+} ratio higher than the safety margin. It led to reduction of citrate flow and bore no clinical consequences of citrate accumulation or hypocalcemia.

In the first part of analysis, the effectiveness of MARS therapy was assessed based on clinical parameters such as encephalopathy reduction, pruritus reduction and diuresis improvement in hepato-renal syndrome. Clinical improvement was observed in 57 (36.1%) sessions.

Considering specific clinical problems, 132 MARS treatments were performed in patients with encephalopathy. Encephalopathy reduction was achieved in 35 (26.5%) cases. In patients with grade I encephalopathy 28 MARS treatments were performed, and 5 (17.8%) were effective. In patients with grade II encephalopathy 39 MARS treatments were performed,

Table 2. Patient characteristics

	ALF			ACLF			AD		
	13 patients (18.8%)			33 patients (50.7%)			16 patients (24.6%)		
F : M	5 : 8			15 : 18			7 : 9		
Age	18.2-74.5 (median = 52.9)			18.7-67.9 (median = 45.6)			19.1-80.6 (median = 51.9)		
MELD	18-49 (median = 29)			16-52 (median = 32)			21-55 (median = 28)		
SAPS	28-75 (median = 51)			25-95 (median = 53)			23-59 (median = 39.5)		
Etiology	– viral	4		– alcohol	14		– alcohol	8	
	– drugs	3		– viral	5		– unknown	3	
	– hemihepatectomy	3		– AIH	3		– AIH	1	
	– others	3		– mixed (alkohol + viruses, drugs + viruses)	3		– viral	1	
				– PBC	4		– hemochromatosis	1	
				– drugs	1		– GvHD	1	
				– hemochromatosis	1		– iatrogenic bile ducts damage	1	
				– iatrogenic bile ducts damage – unknown	1				
Cause of exacerbation				– infection	14		– infection	12	
				– unknown	8		– unknown	3	
				– bleeding esophageal varices	6		– drugs and toxins	1	
				– trauma	3				
				– drugs and toxins	2				
Concomitant diseases	– arterial hypertension	4		– arterial hypertension	8		– arterial hypertension	6	
	– COPD	1		– COPD	4		– diabetes mellitus	5	
	– SAA	1		– diabetes mellitus	3		– COPD	2	
	– cardiomyopathy	1		– thyroid gland disorders	3		– coronary artery disease		
				– colitis ulcerosa	2		– thyroid gland disorders	2	
				– chronic renal failure	1		– epilepsy	1	
				– chronic heart failure	1		– non-Hodgkin lymphoma	1	
				– pancreatitis	1		– pancreatitis	1	
				– peptic ulcer disease	1			1	

Not included in the table:

cholestasis – 2 men, age: 32.5 years (MELD 19, SAPS 23), 33 yrs (MELD 24, SAPS 21, diabetes mellitus); graft failure – PBC, woman, 51.2 years (MELD 36, SAPS 49)

AIH – autoimmune hepatitis, PBC – primary biliary cirrhosis, PSC – primary sclerosing cholangitis, GvHD – graft versus host disease, COPD – chronic obstructive pulmonary disease, SAA – severe aplastic anemia

and 14 (35.9%) were effective. Grade III encephalopathy was an indication for 43 MARS sessions, of which 13 (30.2%) were effective. Grade IV encephalopathy led to 22 sessions, of which only 3 (13.6%) were effective. MARS therapy was very effective in pruritus reduction. Fifteen MARS treatments were performed due to symptomatic pruritus, and 13 (86.7%) sessions were effective. In case of hepato-renal syndrome 44 MARS sessions were performed. Diuresis improvement was observed in 11 (25%) sessions.

In the second part of the analysis, an attempt was made to determine the moment of clinical response in the course of treatment. The aim was to find the optimal therapeutic scheme and determine the validity of further MARS treatment.

After the first MARS cycle, a positive response was noted in 28 (43.1%) patients. In 19 patients encepha-

lopathy reduction was observed, in 6 patients pruritus reduction, and in 5 patients improvement in diuresis. Lack of a positive clinical response was noted in 37 (56.9%) patients.

For the second MARS session, 48 patients were qualified, including 22 patients who responded after the first cycle (responders), and 26 patients without a clinical response (non-responders) after the first cycle. Among responders, 14 (63.6%) improved after the second session, while among non-responders only 4 (15.4%) improved after the second session. The difference is statistically significant ($p = 0.0009$), and it is presented in the diagram (Fig. 1).

For the third MARS treatment, only 27 patients were qualified and a positive response was observed only in 6 (22%) patients. Among responders, 5 (31.2%) of 16 patients who responded in any of the previous

two sessions improved after the third cycle. Among non-responders after 2 sessions, only 1 patient improved after the third MARS cycle. Further MARS treatments were used in a limited number of patients, which precludes detailed analysis. In the analyzed group, only one patient responded clinically just after the fourth or fifth MARS cycle (Fig. 2).

Looking for the relation between a clinical response and a laboratory trend, responders and non-responders were compared. Dynamics of changes in selected laboratory parameters were analyzed in both groups. Statistical significance between groups would indicate the relation between a laboratory trend and a clinical response.

Both in the responder and non-responder group, a statistically significant drop in bilirubin and creatinine level was observed in the course of treatment. ALT, AST or lactate levels did not change significantly in the course of treatment irrespective of response (Table 3).

An attempt was made to characterize the responder group after the whole treatment irrespective of the number of cycles. In this context, demographic, clinical and laboratory data were collected before the start of treatment. The idea was to find statistically significant differences, which would help to understand the mechanism of clinical response.

Responder and non-responder groups did not differ in age ($p = 0.57$), diagnosis ($p = 1.0$), etiology ($p = 0.28$), or SAPS II score at admission ($p = 0.28$). It was determined that the responder group had a significantly lower MELD score compared to the non-responder group ($p = 0.024$). In the analyzed patients, there was no relation between ongoing infection and effectiveness of MARS treatment ($p = 0.80$). Analyzing the laboratory parameters before the treatment, it was observed that responder group had lower initial WBC ($p = 0.025$), AST ($p = 0.027$) and creatinine ($p = 0.031$) levels. There was no difference between groups in initial bilirubin ($p = 0.98$), ALT ($p = 0.52$), urea ($p = 0.13$) or INR ($p = 0.18$) level.
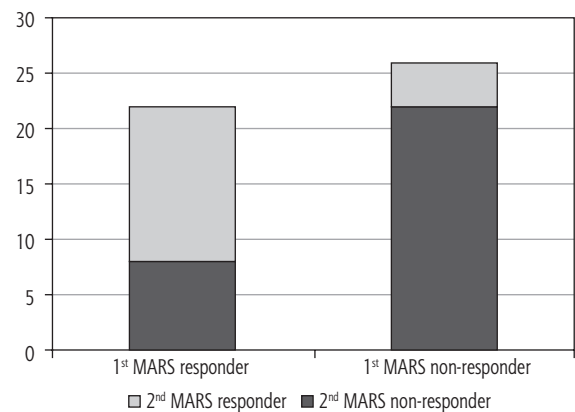

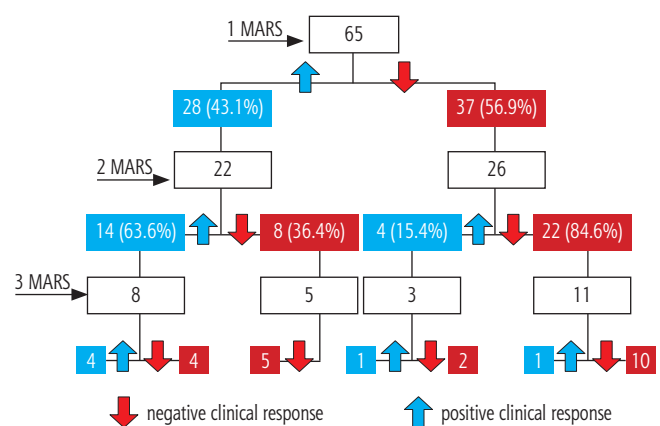**Fig. 1.** Clinical response to 2nd MARS cycle according to response to 1st cycle

Fig. 2. Schematic evaluation of MARS therapy effectiveness

The most important concept of this study was the attempt to create the profile of patients in whom it would be possible to predict a positive clinical response to treatment. To make it possible, multifactorial analysis of pre-treatment characteristics was carried out to determine statistically significant parameters. Low MELD score and low WBC before initiation of treatment were statistically significant parameters of a positive clinical response (Table 4).

Table 3. Changes in selected laboratory parameters in the course of MARS treatment

	Non-responder group			Responder group		
	Min-max (median)		*p*	Min-max (median)		*p*
	Before MARS	After MARS		Before MARS	After MARS	
Bilirubin [mg/dl]	5.9-56.2 (22.6)	3.7-32.3 (17.7)	< 0.0001*	1.9-61.7 (26.1)	2.4-33.7 (15.2)	< 0.0001*
ALT [U/l]	38-3455 (354)	23-1280 (338)	0.382	20-3653 (114)	27-2753 (98)	0.432
AST [U/l]	30-1792 (331)	29-8009 (199)	0.296	20-5179 (137)	21-3652 (126)	0.321
Lactate [mmol/l]	0.8-8.9 (2.7)	0.4-12.9 (2.3)	0.683	0.6-17.0 (1.8)	0.7-20.0 (1.75)	0.398
Creatinine [mg/dl]	0.4-11 (1.8)	0.2-4.9 (1.0)	0.035*	0.2-6.9 (0.7)	0.2-2.6 (0.6)	0.015*

p < 0.05

Table 4. Odds ratio and confidence intervals for factors selected in responder model

	P-value	OR	2.5%	97.5%
Age	0.327	0.98	0.93	1.02
SAPS II	0.201	1.03	0.98	1.09
MELD	0.030*	0.89	0.80	0.98
Encephalopathy	0.566	1.21	0.63	2.42
Hepatorenal syndrome	0.948	0.95	0.19	4.87
Initial WBC	0.036*	0.93	0.86	0.98
Initial bilirubin	0.688	1.01	0.96	1.07
Initial AST	0.286	1.00	1.00	1.00
Infection	0.992	1.00	0.24	4.38

*$p < 0.05$

Discussion

The literature describes the effectiveness of MARS treatment based on clinical parameters, laboratory parameters and influence on mortality [25]. Albumin dialysis plays a very important role as a bridge to liver transplantation [14] and helps to optimize the patient before the surgical procedure. In this context, clinical effectiveness becomes a major issue, not only short-term mortality. Moreover, we could not find in the literature any articles or studies dealing with patient characteristics, that could help clinicians to predict the clinical result of MARS therapy. In this study, we analyzed only patients' clinical improvement and we tried to create a profile of patients with an expected positive clinical response to treatment.

During 8 years, 158 MARS treatments were performed in 65 patients, and 35 (53.85%) patients improved clinically after the treatment. Most patients responded to treatment after just one session. The results clearly show that MARS therapy is very effective in the first cycle and conducting further sessions was not correlated with better clinical outcome.

Analyzing the results in detail, one can notice that the first MARS session is very effective in pruritus reduction, which corresponds to data in the literature [12, 14]. Treatment with MARS is very expensive (in Poland roughly $2500) and using this method in pruritus reduction should be limited to patients without further treatment options.

The treatment was less effective in encephalopathy reduction, although there are many studies pinpointing its efficacy in this clinical situation [12, 26]. Another benefit of qualifying patients with encephalopathy to MARS treatment is the time gain, which can be used for the organ search crucial in the process of liver transplantation [26]. The most difficult group of patients analyzed in our department was that of patients with hepato-renal syndrome. Hepato-renal syndrome is very difficult to differentiate from acute kidney injury; usually the diagnosis is made through exclusion, often retrospectively. By performing MARS therapy in HRS we wanted to use the unique combination of albumin dialysis and continuous veno-venous hemodiafiltration. Studies describing the improvement in clinical parameters, laboratory parameters and mortality reduction or improvement in organ function [13] in HRS patients encompassed small groups of patients. Most of the studies assessing the effectiveness of MARS treatment focus on behavior of laboratory parameters. The uniqueness of our study is based on the fact that we determined the effectiveness of MARS treatment using the clinical response irrespective of the laboratory trend. Such an attitude should be very interesting for any physician dealing with liver failure.

In the literature, albumin dialysis was used randomly in the context of the number of cycles per patient. Our results show that from the clinical point of view, the most valuable is the first MARS cycle. Its ineffectiveness corresponds to a low probability of clinical improvement after further MARS sessions. It seems logical to intensify and continue MARS therapy in ALF, even after failure of the first session of albumin dialysis. It is also crucial to intensify the qualification process for liver transplantation. As far as AD or ACLF is concerned, one should concentrate on looking for the precipitating factor and medical treatment. In our opinion, MARS therapy could be used in persisting liver failure in spite of optimal treatment. Of course, encephalopathy is the most important symptom; deterioration in neurological status is sufficient for starting MARS therapy. Our results might be helpful in determining the optimal treatment protocol with albumin dialysis and its cost-effectiveness.

Another difficult question to answer is whether there is any correlation between laboratory parameters and clinical response. Such a correlation would help clinicians to plan the treatment and decide when to continue and when to stop the treatment. Researchers usually focus on the detoxifying capacity of albumin dialysis [25] or correlate laboratory parameters with clinical response during the search for factors of a positive outcome [27]. Analyzing the laboratory trend based on the clinical response, we did not find such a correlation.

The strength of this study is the attempt to create a patient profile for maximum benefit of MARS treatment. We were looking for patient characteristics that would enable us to predict a clinical response. In statis-

tical analysis, we included demographic data, etiology, the presence of a precipitating factor and symptoms of liver failure and of course laboratory parameters. In the responder group lower MELD score, lower WBC and AST showed statistical significance.

Thinking about the possibility of creating a profile of patients who would benefit from MARS therapy, we conducted a multifactorial analysis of the positive response to albumin dialysis. On the basis of our analysis, we determined that lower WBC ($p = 0.0356$) and lower MELD score ($p = 0.0302$) predispose to a positive clinical response. It might be suspected that it is strictly correlated with stability of the patient. Our results clearly show that the more stable the patient is, the better the chance of successful treatment. The small group of patients precludes establishing cut-off values of MELD or WBC for a positive or negative treatment response. High WBC might suggest some inflammatory process irrespective of the presence of infection. MELD score, beside its use in organ allocation, has predictive value in many clinical situations (infections, varicose vein bleeding, fulminant hepatitis or alcoholic hepatitis).

Eight-year analysis of liver failure patients performed by our team is the clinical point of view looking at the problem of qualification, optimization and effectiveness of treatment. This analysis has some important limitations. It was done on a rather small group of patients treated in a long period of time. We analyzed ALF, ACLF, and AD patients together, which is a very important limitation because these entities have different prognoses, but our goal was to assess clinical effectiveness, not mortality. In eight years, standard medical therapy evolved as well as diagnostic and microbiology tests. We changed invasive hemodynamic monitoring for noninvasive monitoring, with ultrasound becoming our standard method. It might be that standard therapy and diagnostic accuracy had an influence on clinical response to treatment. To minimize the effect of standard medical therapy, we analyzed only symptoms of liver failure just before initiation of MARS treatment and the potential clinical response just after completion of albumin dialysis. The small group of patients made it impossible to analyze the data according to the diagnosis. Analysis of the effects of therapy in ALF, ACLF and AD would be very interesting, as well as analysis according to the etiology of liver failure, but is impossible to perform in a reliable way. Because many patients did not have any diagnostic tests before ICU admission, it was very difficult to assign them to particular groups. All these problems could have influenced our system of qualification. The most problematic was differentiation between ACLF and AD. Acute

decompensation was defined as liver failure without organ failure, whereas ACLF was defined as liver failure with organ failure. It might be oversimplified but it was very helpful in patient assessment.

Another limitation is the description of clinical effectiveness. Such description was done by different clinicians with different experience in treating liver failure patients. The most problematic was assessment of encephalopathy based on 4 elements: impairment of autonomy, changes in consciousness, intellectual function and behavior. Many patients did not have such a thorough evaluation and encephalopathy grading was done on the basis of one or two elements. Despite the basic evaluation of encephalopathy, the trend in symptoms could be easily determined.

It is worth mentioning that it would be very helpful to analyze additional laboratory findings such as factor V or ammonia levels. These parameters were not included in our study because our laboratory did not measure them around the clock, but only in the working hours. Moreover, factor V and ammonia levels appeared in our laboratory measurements in 2011, so it would be impossible to reliably include them in the study. We did not include albumin level because it represents liver function in the long term and the level of albumin can change during any artificial organ support. Our experience shows that CVVHDF is effective in reducing ammonia levels. Similar observations could be found in the literature [28]. Maybe MARS combined with CVVHDF is not the best method to quickly lower ammonia levels compared to high flux dialysis [29] or plasma exchange with fresh frozen plasma replacement [30], but continuity of CRRT provides good control of acid-base and fluid balance in unstable patients.

Of 158 MARS sessions, 32 (20.2%) were performed with transfusion of blood products such as packed red blood cells, fresh frozen plasma, cryoprecipitate or platelets, which could have influenced coagulation screening. It was the reason why we did not include INR, platelets or hemoglobin in our analysis.

Our analysis did not include long-term mortality due to the lack of contact information with patients or their families. In spite of the fact that MARS treatment does not influence mortality according to the literature, it would be interesting to know what happened to patients after ICU treatment. We managed to send 5 patients for liver transplantation, but the process of qualification is very difficult from the ICU perspective. The transplantation centers require a stabilized patient without any kind of organ support, so our goal was to perform MARS therapy and send patients to hepatology units for further assessment. From this approach

comes another limitation. It is impossible to assess the length of hospital stay or length of organ support in such a diverse group of patients.

Conclusions

MARS therapy is an effective form of treatment in a properly selected group of patients with liver failure. It is highly effective in pruritus reduction, less effective in encephalopathy reduction, and raises doubts in the treatment of HRS. The first MARS session is the most effective one. It is also a good prognostic factor of a further clinical response to treatment. There is no correlation between clinical response and laboratory parameters during the treatment. Multifactorial analysis of the positive clinical response to treatment enables one to create a patient profile based on lower baseline MELD score and lower baseline WBC.

Disclosure

The authors report no conflict of interest.

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