

## Research Article

# Burn Resuscitation with Fresh Frozen Plasma: 5 Years of Experience with the West Penn Formula

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## Abstract

**Introduction:** Administering fresh frozen plasma (FFP) for burn resuscitation following the West Penn Formula was first described by Du, et al. in 1991 and subsequently by O'Mara et al. in 2005. Since 2006, the O'Mara modification has been followed for the resuscitation of large burns (>40% TBSA or 30% TBSA with concomitant inhalation injury) at our institution. This is a report of our initial 5 years' experience with a comparison of our outcomes to those reported by Du and O'Mara.

**Methods:** A retrospective chart review of burn admissions between February 1, 2005 and August 31, 2011, revealed 62 patients suffered large burns and received fluid resuscitation following the West Penn Formula.

**Results:** Average TBSA was  $52 \pm 18.9\%$  (average full thickness  $28.1 \pm 27.6\%$ ). Thirty-six (58%) suffered inhalation injury. Average FFP infusion was  $3.2 \pm 2.4$  liters/24hrs. Urine output averaged  $1.1 \pm 0.7$  cc/kg/hr. Average base deficit at 24 hours was  $1.6 \pm 6.1$ . Ten deaths occurred during the first 48 hours post burn all due to requests of family members to withdraw support.

**Conclusions:** The West Penn Formula appears to be an effective method to resuscitate patients suffering burn shock secondary to major burns.

**Keywords:** Burn shock; Fresh frozen plasma; Resuscitation

## Introduction

For years the burn community has sought the perfect fluid resuscitation formula to treat patients experiencing burn shock. The goal is to maintain tissue perfusion while avoiding over or under resuscitation and the complications associated with each. Since its introduction in 1968, the Parkland Formula has been the most widely used resuscitation formula by burn surgeons to resuscitate burn patients [1]. The initial Parkland Formula included colloid administration during the second 24 hour period of burn resuscitation [2]. In 1979 a Consensus Formula was introduced by the American Burn Association which excluded the use of colloid [3]. As stated in that report:

*"It is the consensus that treatment should be begun with a balanced salt solution, such as Ringer's lactate or one of its several equivalents... The volume of fluid to be administered in the first 24 hours ranges between 2 to 4 ml/kg/% burn."*

*"Colloid is generally incorporated in the regimen; however, the exact timing of its administration cannot be set rigidly. It is generally prescribed after the first 24 hours of resuscitation, and whether or not earlier administration is beneficial has not been truly established."*

The use of colloid is also excluded from the American Burn Association sponsored Advanced Burn Life Support Course [4]. It is believed this exclusion of colloid has led to "fluid creep" and the subsequent questioning by several investigators of the efficacy of the Parkland Formula [5-10]. "Fluid creep", which is merely the over resuscitation of burn patients, increases the risk of developing

pneumonia, bloodstream infections, acute respiratory distress syndrome, multiple system organ failure and death [11].

In 1991, Du, et al. described the use of fresh frozen plasma (FFP) as the primary fluid for burn resuscitation [12]. This formula has subsequently become known as the West Penn Formula, named after The Western Pennsylvania Hospital in Pittsburgh where the work was performed. This report of 10 patients showed that smaller amounts of fluid, in the form of FFP, could be used successfully for burn shock resuscitation while avoiding excessive fluid administration and weight gain. A follow-up report by O'Mara in 2005 demonstrated the West Penn Formula to be effective in resuscitating patients from burn shock while at the same time avoiding the complications of intra-abdominal hypertension and abdominal compartment syndrome [13].

Since 2006, the West Penn Formula has been used for resuscitation of large burns (>40% total body surface area or 30% total body surface area with inhalation injury) at The Ohio State University Wexner Medical Center. The resuscitation is carried out following the formula as described by O'Mara, et al. of 75cc FFP/kg bodyweight/24 hours administered over the initial 48 hours plus Lactated Ringer's Solution at 83cc/hr (2 liters over 24 hours X 48 hours) [13]. The FFP is titrated to maintain a urine output of at least 0.5cc/kg bodyweight/hour. To date, no one has described the use of the West Penn Formula in a large sample size nor compared its use to resuscitation following the Parkland Formula. The primary objective of this study was to describe our experience with the West Penn Formula and compare our outcomes with those reported by both Du and O'Mara [12,13]. Secondary objectives were to compare the total amount of fluid given

**Table 1:** Comparison of baseline characteristics.

Variable	Du <sup>12</sup> N=10	O'Mara <sup>13</sup> N=16	Ohio State N=62
Inclusion	30% TBSA	40% TBSA, 25% TBSA with inhalation injury	40% TBSA, 30% with inhalation injury
Age	42.7 +/-4.1	44.6 +/- 19.3	51.1 +/- 17.2
% TBSA	43.5 +/-3.89	52.1 +/- 12.4	52 +/- 18.9
% Full thickness	22 +/-4.13	29 +/- 18.9	28.1 +/- 27.6
Inhalation injury		10 (62.5%)	36 (58%)
Deaths	2 (20%)	3 (18.75%)	33 (53.2%) total 10 (16.1%) 1 <sup>st</sup> 48 Hrs

**Table 2:** Comparison of resuscitation parameters.

Variable	Du <sup>12</sup> N=10	O'Mara <sup>13</sup> N=16	Ohio State N=62
FFP infusion	75cc/kg x 36 hrs	75cc/kg x 48 hrs (titrated to U.O.) +LR @ 83cc/hr	75cc/kg x 48 hrs (titrated to U.O.) +LR @ 83cc/hr
FFP ml/kg/% TBSA	2.68 +/-0.23		1.4 +/- 0.70
FFP infused (24 hr total)		12.3L +/-9.3	3.2L +/-2.4
Parkland predicted		17.1 +/- 6.4	18.2 +/-8.9
U.O. 24 hr cc/kg/hr		0.76 +/- 0.33	1.1 +/- 0.7
Base deficit (mean)		3.6 +/- 2.5	1.6 +/- 6.1
BUN (mean)		24.6 @ 48 hrs	25 @ 48 hrs
Serum Creatinine (mean)		1.48 @ 48 hrs	1.5 @ 48 hrs

using the West Penn Formula with Parkland Formula calculations, identify complications associated with FFP resuscitation, describe endpoints of resuscitation such as urine output, serum creatinine and BUN and examine mortality experienced with FFP resuscitation.

## Methods

Following IRB approval, a retrospective chart review was conducted of patients with large burns resuscitated using the West Penn Formula admitted to the verified burn center at The Ohio State University Wexner Medical Center between February 01, 2006 and August 31, 2011. Inclusion criteria included only acute burns of > 40% total body surface area or 30% total body surface area with an associated inhalation injury. Exclusion criteria included prisoners and pregnant females. Data was collected by retrospective chart review. Data points collected included total body surface area burn (TBSA), presence of inhalation injury, hourly fluid intake and urine output for the first 48 hours post admission, base deficit, BUN, creatinine, mortality, and cause of death. Predicted Parkland Formula fluid administration was also calculated and compared to the amount of FFP actually given. Deaths were divided into those who died within the first 48 hours post burn and those who died after 48 hours. Descriptive statistics were used since the primary objective was to describe our experience using the West Penn Formula for resuscitation. Age, gender, inhalation injury, TBSA, partial thickness size, and full thickness size were compared to assess if statistically significant differences were present. Age and TBSA were compared between the two groups using two sample t-tests. Comparisons of partial and full thickness were made using Mann-Whitney U tests due to non-normality of the data. Comparisons for gender and inhalation injury were made using Fisher's Exact Test. Statistical analysis was done using SAS 9.3.

## Results

There were 62 patients (42 males, 20 females) who met inclusion

criteria of a large burn receiving fluid resuscitation following the West Penn Formula. Average age was 51.1±17.2 years. Average TBSA was 52±18.9 % with an average of 28.1±27.6% being full thickness. Thirty-six (58%) suffered inhalation injury which was diagnosed with bronchoscopy. The baseline characteristics of these patients, with a comparison to patients reported by Du, et al. and O'Mara, et al. are listed in Table 1 [12,13].

Following the formula of 75cc/kg bodyweight/24 hours X 48 hours plus Lactated Ringer's Solution at 83cc/hr., our patients received an average of 1.40±0.70ml/kg bodyweight/% TBSA of FFP. In the initial 24 hours post burn, they received an average infusion of 3.2±2.4 liters of FFP. Application of the Parkland Formula to these same patients would have resulted in a crystalloid infusion of 18.2±8.9 liters. Urine output of our patient's averaged 1.1±0.7cc/kg bodyweight/hr. Base deficit at 24 hours was 1.6±6.1. At 48 hours post burn the mean BUN was 25 and the mean serum creatinine was 1.5. A comparison of resuscitation data point scan is found in Table 2.

There were a total of 33 deaths in our study group. Ten occurred in the first 48 hours post burn with the remaining 23 occurring afterward. Males accounted for 19 of the deaths. The average burn size (TBSA) of those patients who died was 54% (range 29.8 to 87.5) with mean partial thickness TBSA of 14.9% (range 0 to 53.5) and mean full thickness TBSA of 35.8% (range 0 to 83.9). Only 9 of the patients who died had suffered an inhalation injury. Table 3 is a listing of all of our deaths along with a comparison of those deaths that occurred during the resuscitation period of 48 hours post burn with those that occurred later. No significant differences were found in the proportion of males and females between groups or the proportion of inhalation injuries. There was also no statistically significant difference in age, TBSA, or partial thickness. There was evidence that those who died in the first 48 hours had larger full thickness burns, (p=0.0334).

## Discussion

The modern search for the ideal burn shock resuscitation formula

**Table 3:** Comparison of deaths at The Ohio State University Wexner Medical Center.

Variable	All deaths N=33 mean (range)	Deaths 1 <sup>st</sup> 48 hrs N=10 mean (range)	Deaths after 48 hrs N=23 mean (range)	p- value
Age	57.96 (20.9 to 92.5)	61.48 (20.9 to 92.5)	56.65 (25.3 to 80)	0.8661
Males	19	6	13	1.0000
Females	14	4	10	
Inhalation injury	Yes =9, No=22	Yes =4, No=6	Yes =5, No=18	0.0816
TBSA	54.0 (29.8 to 87.5)	62.6 (37.3 to 87.5)	50.3 (30to 84.9)	0.0767
Partial thickness	14.9 (0 to 53.5)	8.25 (0 to 26)	18.75 (0 to 53.5)	0.0810
Full thickness	35.8 (0 to 83.9)	54.4 (15 to 82)	31.1 (0 to 83.9)	0.0334
Cause of death		Withdrawal = 10	MSOF=13 Sepsis =8 Resp. failure =1 Withdrawal = 1	

dates to the Rialto Theater fire in New Haven, Connecticut in 1921 and observations made by Dr. Frank Underhill in treating the victims. He stated that “the systemic treatment in the early stage is of much greater significance than the treatment of the injured surface” [14]. Several years later, Dr. Henry Harkins was the first to propose the use of plasma as the primary ingredient in burn resuscitation fluid [15,16]. His work carried over to that of Cope and Moore who, following the Cocoanut Grove fire in 1942, proposed a combination of plasma and isotonic electrolyte solution [17]. In 1952, Evans proposed the Surface Area-Weight Formula that also used colloid, or blood, with normal saline and glucose [18]. In the conclusion to that report Dr. Evans noted:

*“Hourly clinical observation is exceedingly important. The decisions of clinical management of fluid therapy take precedence over the precise application of any formula.”*

In 1968, Baxter and Shires proposed what has become known as the “Parkland Formula” [2]. This formula relies solely upon crystalloid for the first 24 hours of resuscitation with the addition of plasma during the fourth 8 hour period of resuscitation. In a recent survey conducted by Greenhalgh, the Parkland Formula was recognized by burn surgeons as the most commonly used formula for resuscitation from burn shock [1]. In that same report, however, 20.8% of respondents said they utilize albumin and 13.9% utilize fresh frozen plasma in their resuscitation efforts.

Recently, the efficacy of the Parkland Formula has come under scrutiny [6-10]. However, as noted by Saffle, the formula being used in most instances is the American Burn Association Consensus Formula which differs from the original Parkland Formula by not including any type of colloid as a resuscitation fluid [5]. It is believed this exclusion of colloid administration in burn resuscitation may explain the phenomenon of “fluid creep” described by Pruitt [6]. Indeed, several authors [19-22] have recently reported the utility of including colloid in burn resuscitation, most commonly albumin, with the report by Lawrence, et al. concluding,

*“The addition of colloid to Parkland resuscitation rapidly reduces hourly fluid requirements, restores normal resuscitation ratios, and ameliorates fluid creep”.*

In 1991, Du et al. published *Influences of Different Resuscitation Regimens on Acute Early Weight Gain in Extensively Burned Patients* in which patients received fresh frozen plasma (FFP) at a rate of 75cc

per kilogram bodyweight over a 36 hour period [12]. They were able to show a statistically significant minimal weight gain in patients resuscitated with FFP. In a follow-up report by O’Mara, et al. the West Penn Formula was modified to FFP at a rate of 75cc per kilogram bodyweight over 24 hours along with Ringer’s lactate at 83cc per hour [13]. The FFP is titrated to a rate that produces urine output of 0.5 to 1.0 cc per kilogram bodyweight per hour and is continued for 48 hours post-burn. At the end of that time, the patient receives crystalloids at a maintenance rate with continued clinical monitoring. O’Mara’s report showed that resuscitation could be successful with the West Penn Formula while at the same time avoiding intra-abdominal hypertension and abdominal compartment syndrome [13]. Our experience also demonstrated that no patient developed intra-abdominal hypertension or abdominal compartment syndrome.

Since 2006, the West Penn Formula has been used at The Ohio State University Wexner Medical Center for the resuscitation of patients with large burns of greater than 40% TBSA or greater than 30% TBSA with concomitant inhalation injury. During our first 5years of experience with the West Penn Formula, 62 patients with burns fitting that definition were resuscitated using that formula. A comparison of our study population with those reported by Du et al. and O’Mara et al. reveals great similarity across the three reports (Table 1) [12,13].

In the O’Mara report and our patient group the predicted amount of crystalloid as calculated by the Parkland Formula was 17.1±6.4 and 18.2±8.9 liters respectfully for the first 24 hours following the injury [13]. The amount of FFP administered in the first 24 hours by O’Mara was 12.3±9.3 liters [13]. Our experience found FFP administered in the first 24 hours to be 3.2±2.4 liters. The lesser amount administered to achieve adequate urine output in our experience may reflect the crystalloid administered to patients prior to arriving at our hospital (mean 2835cc, range 200– 13000cc) and the initiation of FFP resuscitation. Despite the lower amount of FFP administered, other parameters used to evaluate fluid resuscitation were similar. The blood urea nitrogen (BUN) and serum creatinine of our patients and those reported by O’Mara were nearly identical at the end of the resuscitation period (Table2) [13].

The death rates reported by Du (2 of10, 20%) and O’Mara (3 of 16, 18.75%) may reflect the small sample sizes in those reports [12,13]. Our death rate was 33 of 62 (53%) overall, but only10 of 62 (16.2%) occurred during the resuscitation period of the first 48 hours

post burn (Table3). None of the early deaths were the result of failure to resuscitate but rather followed the requests of family members to withdraw support. All 10 of these patients received full and aggressive resuscitative support following the West Penn Formula until the family request was made.

A limitation of this study is that it is a retrospective chart review. Therefore, sample size may not be large enough to draw conclusions despite this being the largest cohort of patients reported in the literature that were resuscitated using FFP and the West Penn Formula. Our findings corroborate the findings of both Du and O'Mara. Because this was a descriptive study, a larger prospective study at multiple sites would be helpful in comparing burn resuscitation formulas.

## Conclusion

The 62 patients in this study constitute the largest series of burn patients resuscitated with FFP following the West Penn Formula reported in the literature. The results of this study, when compared to the two previous studies pertaining to the West Penn Formula, confirm those earlier reports. The West Penn Formula, utilizing colloid in the form of FFP, appears to be an effective method to resuscitate patients suffering burn shock secondary to major burns. These results suggest a prospective study be performed randomizing patients into a Parkland Formula resuscitation group or a West Penn Formula resuscitation group creating a head-to-head comparison of the two methods.

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