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Renal resistive index: a tool for postoperative intensive care unit-outcome? a pilot observational study

Abstract

We report the results of an observational analysis about the post-intensive care outcome in high-risk patients submitted to major oncologic surgery who needed of intensive care surveillance and/or treatment during the 1st postoperative week. Given the acute kidney injury is a poor prognostic factor and is one of the most frequent post-surgical complication, we measured renal resistive index by color-Doppler ultrasound within six hours from the ICU admittance of 146 patients submitted to major surgery due to neoplasm, hypothesizing that high RRI may be correlated with mortality. We found a significant difference of renal resistive index in patients who died compared to survived subjects: 0.74±0.06 vs 0.66±0.08, p<0.001. Furthermore, RRI>0.70 may be a reasonable cutoff value to predict a significant increase of mortality risk.

Keywords: Outcome; Renal resistive index; Acute kidney injury; Major surgery

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Enrico Giustiniano,[1] Nadia Ruggieri,[1] Massimo Meco[2]

[1]Department of Anesthesia and Intensive Care, Humanitas Research Hospital, Italy
[2]Cardiac Surgery Anesthesia Unit, Sant'Ambrogio Clinical Institute, Italy

Correspondence: Enrico Giustiniano, Humanitas Research Hospital-Department of Anesthesia and Intensive Care, via Manzoni 56, 20089, Rozzano (Milan), Italy, Tel +39 02 8224 7459, Fax +39 02 8224 4190, Email enrico.giustiniano@humanitas.it

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Abbreviations: RRI, renal resistive index; ICU, intensive care unit; ASA, american society of anaesthesiology score; AKI, acute kidney injury; SIRS, systemic inflammatory response syndrome; NGAL, neutrophil gelatinise-associated lipocalin

Introduction

Major non-cardiac surgery in ASA 3-patients may be very challenging regarding the postoperative outcome. A period of monitoring and/or treatment in intensive care unit (ICU) is recommended. But it faces the bed-availability of critical care units, which is a serious issue everywhere. The optimization of intensive-care beds' turnover needs of tools aimed to predict whether patients will really need or not of ICU admittance postoperatively.

Renal Resistive Index (RRI) measures the resistance of arterial blood flow of the kidney. In normal conditions, flow through the renal artery occurs throughout systole and diastole. A variety of conditions (shock, inflammation, obstruction, etc.) determine a reduced or even reversed flow through the renal artery during diastole. In these cases, RRI increases.[1,2] Acute kidney injury (AKI) is a complex adverse event due to systemic inflammatory response syndrome (SIRS) with consequences on remote organ function such as heart, lung, brain and gastro-enteric tract.[3,4] Furthermore, AKI is a poor prognostic factor and RRI is an early detective parameter of renal impairment.[5–7] We retrospectively searched for the potential relationship between the early measurement of RRI and the outcome in ICU-admitted patients postoperatively, due to major surgery in high risk subjects or suffering from cardio-respiratory failure due to postoperative severe sepsis.

Materials and methods

We measured RRI in a mixed sample of 146 consecutive ASA 3 patients, aged 72years (range 55÷82years) within 6hours from the admittance to our ICU. The sample population included patients with high per operative risk due to comorbidity. They entered ICU during the 1st postoperative week as they deserve a post-surgical intensive monitoring and treatment due to initial hemodynamic and/or respiratory impairment (systolic blood pressure 90-100mmHg, peripheral oxygen saturation 90-95%, respiratory rate 20-25apm, oliguria without serum creatinine rising). Before any vasoactive drug administration, all the patients were submitted to ultrasound color-Doppler measurement of renal resistive index. Fluid administration challenge and non-invasive/invasive respiratory support were permitted before RRI measurement. RRI was measured always by the same operator to reduce the bias due to operator-dependent experience, using the convex probe C6-2 of the Sparq Ultrasound System (Philips Ultrasound, 22100 Bothell-Everett Highway, Bothell, WA, 98021-8431, USA).

We explored the relationship between RRI at ICU admittance and the mortality during the intensive care unit staying. The calculation of the sample size result 96 patients (Power's study 90%; Confidence Interval 95%; Expected difference between the groups 10%). Results are reported as median and range or average and standard deviation. We adopted the Student's t-test or Fisher's exact test as appropriate for the statistical analysis. We performed the ROC curve searching for a cutoff value of RRI with a good sensitivity and specificity. For the statistical analysis we used Stata 13, Software-Stata Corp. 4905 Lake way Drive College Station, Texas 77845-4512 USA.

Results

Out of 146 patients, 98 underwent gastro-intestinal resection surgery, 19 Esophagectomy, 5 Hepatic neoplasm resection, 7 Pneumonectomy, 6 Lung-Lobectomy and 11 pancreatic resection. Regarding the outcome, 23 (16.3%) died during ICU staying and 123 returned to ward after recovery from the critical illness. Results are reported in table 1. Patients who died showed an RRI significantly higher compared with survived patients: 0.74+0.06 vs 0.66+0.08, p<0.001. Patients with a poor outcome died within 2-11days (median 3days). Conversely, patients with a good outcome returned to ward after 1-5days (median 1 day).

Figure 2 shows the ROC curve that seems to confirm the cutoff value of RRI reported in previous studies as predictive of adverse events (Area under the ROC curve 0.794; 95% confidence interval 0.719 to 0.856; p<0.0001). Patients who showed RRI>0.70 were 48 (32.8%): 18 (12.3%) subjects died. Among patients with RRI<0.70 (n=98) only 5 (3.4%) died; p<0.001.

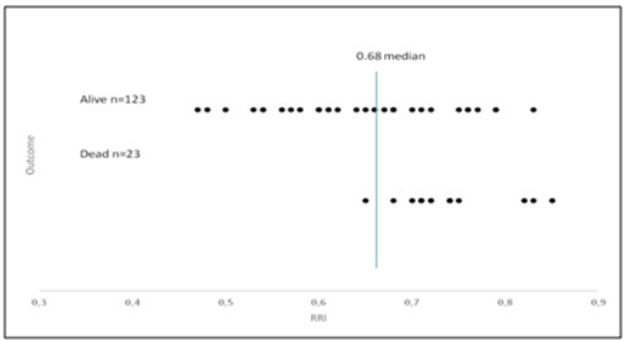

Figure 1 N=57; Epidemiological distribution of the pathological fractures, traumatic fractures, and nonunion.

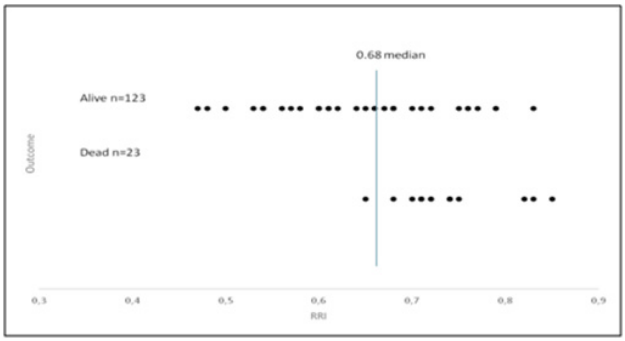

Figure 2 The ROC curve.

Table 1 Results

	Alive (n=123)	Alive (n=123)	p
Median RRI	0.68	0.72	
Max value RRI	0.88	0.88	
Min value RRI	0.47	0.65	
Average RRI (standard deviation)§	0.66 (0.08)	0.74 (0.06)	<0.001
RRI≤0.70 (n)#	93	5	<0.001
RRI>0.70 (n)#	30	18	<0.001
Length-of-Stay in ICU (days)*	1(1÷5)	3(2÷11)	<0.001

§Student's t-test

#Fisher's exact test

*Median and range

RRI: Renal Resistive Index

Discussion

The increase of resistances to renal blood flow is an early epiphenomenon of several extra-renal disease during which a constriction of the arterial circulation is a response to hemodynamic impairment (low-flow state, severe sepsis and septic shock, for instances). RRI is a sonographic measurement of such vasoconstriction. Then we investigated whether it may be considered a predictive index of postoperative outcome after ICU admittance in high-risk patients submitted to major surgery. We found a significant difference between RRI in patients who survived compared to RRI of subjects who died.

Literature reports RRI as a predictive marker of acute renal impairment. Acute kidney injury is an adverse event that may critically and severely complicate also the outcome of surgical patients submitted to a major operation, both in cardiac and non-cardiac surgery. Nowadays several markers of AKI are available. Despite neutrophil gelatinase-associated lipocalin (NGAL) or Cystatin C are able to detect AKI earlier than serum creatinine, Renal Resistive Index may disclose it more precociously because it can detect the renal impairment at the beginning, when renal arterial vessels constrict.[1,2,8,9]

There is a general consensus about a cutoff range of RRI 0.70÷0.74 to define patients exposed to a significant risk of AKI or other adverse events after major surgery.[10,11] In our sample the median value was a little lower (RRI 0.68) than the cutoff. But we found that almost all patients with RRI<0.68 experienced a good outcome and were dismissed to ward. Conversely, RRI>0.68 may be not equally strongly related to a poor outcome. The ROC curve analysis indicated that RRI<0.70 may be a reasonable value to define a low-risk profile regarding the outcome after ICU-admittance due to major surgery in patients with severe co-morbidities. Such a value is in line with previous reports. But, at our knowledge, no results about the relationship between RRI and post-operative mortality had been published. The enrolled sample underwent high-risk surgery. It implies a serious risk of poor outcome even in ASA 1 patients, also because it is major oncologic surgery in elderly subjects who often received chemotherapy and/or radiant therapy, preoperatively. Consequently, we consider that an early marker of high risk situation may be very helpful to manage the case.

Further, RRI is a not invasive and simple measurement. Like all ultrasound exams, also RRI may be operators experience-dependent, but it has been showed that after attending a half-day training, RRI can be measured with a good feasibility and reliability.[12] Our study has many limitations, but the most significant are the two following issues. First, it is a small observational analysis in a pilot study. Second, the enrolled population was a case-mix sample and consequently results are probably affected by the in-homogeneity of the patients.

Conclusion

Despite such limitations, we may conclude that a RRI greater than 0.7 may early detect a critically ill patient with a high risk of poor outcome after major oncologic surgery and admitted to ICU postoperatively. We are aware that prospective trials exploring the potential role of RRI to predict the postoperative outcome are desirable and our trial may be a promising starting point.

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Conflicts of interest

Author declares there are no conflicts of interest.

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