

PULSION Medical Systems

LiMON-Technology Literature List

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- Very Highly Recommended
- Highly Recommended
- Recommended

'This document is intended to provide information to an international audience outside of the USA'

1. REVIEWS

Mobley CM and Zarrinpar A

Portable Device for the Analysis of Liver Function: A Boon to Liver Surgery and Critical Care

Expert Rev Med Devices 2015: epub

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Halle BM, Poulsen TD, Pedersen HP

Indocyanine green plasma disappearance rate as dynamic liver function test in critically ill patients

Acta Anaesthesiol Scand 2014; 58(10): 1214-9

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Sakka SG.

Assessing Liver Function

Curr Opin Crit Care 2007; 13(2):207-14

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Bauer M, Winning J, Kortgen A

Liver Failure

Curr Opin Anaest 2005; 18:111-6

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Sakka SG, Meier-Hellmann A

Non-invasive liver function monitoring by indocyanine green plasma disappearance rate in critically ill patients

Int J Intensive Care 2002; 9(2):66-72

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2. BACKGROUND

2.1 Pathophysiology

Kortgen A, Paxian M, Werth M, Recknagel P, Rauchfu F, Lupp A, Krenn CG, Muller D, Claus RA, Reinhart K, Settmacher U, Bauer M

Prospective assessment of hepatic function and mechanisms of dysfunction in the critically ill.

Shock 2009; 32(4): 358-65.

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Sander M, Krimphove M, Spies C

Increasing Regional Blood Flow: The Splanchnic Region

In: Vincent JL (Ed.), Yearbook of Intensive Care and Emergency Medicine 2004: 473-86

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2.2 Technology / Validation

Purcell P, Kruger P, Jones M

Indocyanine green elimination: a comparison of the LiMON and serial blood sampling methods

ANZ J Surg 2006; 76: 75-7

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Sakka SG, van Hout N

Relation between indocyanine green (ICG) plasma disappearance rate and ICG blood clearance in critically ill patients.

Intensive Care Med 2006; 32(5):766-9

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Sakka SG, Koeck H, Meier-Hellmann A

Measurement of indocyanine green plasma disappearance rate by two different dosages

Intensive Care Med 2004; 30(3):506-9

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Faybik P, Krenn CG, Baker A, Lahner D, Berlakovich G, Steltzer H, Hetz H

Comparison of invasive and noninvasive measurement of plasma disappearance rate of indocyanine green in patients undergoing liver transplantation: a prospective investigator-blinded study

Liver Transpl 2004; 10(8):1060-4

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Sakka, SG, Reinhart K, Meier-Hellmann A

Comparison of invasive and noninvasive measurements of indocyanine green plasma disappearance rate in critically ill patients with mechanical ventilation and stable hemodynamics

Intensive Care Med 2000; 26(10): 1553-6

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2.3 Indocyanine Green

Leevy CM, Leevy CB, Howard MM

Indocyanine green and the liver

In: Davidson CS (Ed.), Problems in Liver Diseases, 1979, Georg Thieme Publishers Stuttgart-New York; 42-52

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Paumgartner G, Probst P, Kraines R, Leevy CM

Kinetics of Indocyanine green removal from the blood

NY Acad Sci 1970; 170:134-47

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3. FIELDS OF APPLICATION

3.1 Intensive Care Medicine

3.1.1 Cardiac Surgery

Weis F, Kilger E, Beiras-Fernandez A, Hinske CL, Nassau K, Adnan L, Vicol C, Kur F, Mohnle P

Indocyanine green clearance as an outcome prediction tool in cardiac surgery: A prospective study

J Crit Care 2014; 29(2): 224 – 9

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Tomasa TM, Moreno JA, Just MS, Cubells C, Camara ML, Roca J, Fernandez-Llamazares J

Indocyanine green plasma disappearance rate predicts cardiac surgery stay

Experimental & Clinical Cardiology 2014; 20(7): 838-55

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Sander M, Spies CD, Berger K, Schroder T, Grubitzsch H, Wernecke KD, von Heymann C

Perioperative indocyanine green clearance is predictive for prolonged intensive care unit stay after coronary artery bypass grafting - an observational study

Crit Care 2009; 13(5): R149

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Sander M, Spies CD, Foer A, Syn DY, Grubitzsch H, Von Heymann C

Peri-operative plasma disappearance rate of indocyanine green after coronary artery bypass surgery

Cardiovasc J Afr 2007;18(6): 375-9

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Sakka S, Hofmann D, Thuemer O, Schelenz C, Van Hout N

Increasing cardiac output by epinephrine after cardiac surgery: effects on indocyanine green plasma disappearance rate and splanchnic microcirculation

J Cardiothorac Vasc Anesth 2007; 21(3):351-6

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Hofmann D, Thuemer O, Schelenz C, van Hout N, Sakka SG

Increasing cardiac output by fluid loading: effects on indocyanine green plasma disappearance rate and splanchnic microcirculation

Acta Anaesthesiol Scand 2005; 49: 1280-6

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3.1.2 Sepsis And Septic Shock

Hernandez G, Bruhn A, Luengo C, Regueira T, Kattan E, Fuentealba A, Florez J, Castro R, Aquevedo A, Pairumani R, McNab P, Ince C

Effects of dobutamine on systemic, regional and microcirculatory perfusion parameters in septic shock: a randomized, placebo-controlled, double-blind, crossover study

Intensive Care Med 2013; 39(8): 1435-43

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Hernandez G, Regueira T, Bruhn A, Castro R, Rovegno M, Fuentealba A, Veas E, Berrutti D, Kattan E, Martin C, Ince C

Relationship of systemic, hepatosplanchnic, and microcirculatory perfusion parameters with 6-hour lactate clearance in hyperdynamic septic shock patients: an acute, clinical-physiological, pilot study.

Ann Intensive Care 2012; 2(1): 44

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Memis D, Inal MT, Sut N

The effects of levosimendan vs dobutamine added to dopamine on liver functions assessed with noninvasive liver function monitoring in patients with septic shock

J Crit Care 2012;27(3): 318.e1-6

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Inal MT, Memis D, Kargi M, Sut N

Prognostic value of indocyanine green elimination assessed with LiMON in septic patients

J Crit Care 2009; 24(3): 329-34

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Kortgen A, Paxian M, Werth M, Recknagel P, Rauchfu F, Lupp A, Krenn CG, Muller D, Claus RA, Reinhart K, Settmacher U, Bauer M

Prospective assessment of hepatic function and mechanisms of dysfunction in the critically ill

Shock 2009; 32(4): 358-65

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Poeze M, Solberg BC, Greve JW, Ramsay G

Monitoring global volume-related hemodynamic or regional variables after initial resuscitation: What is a better predictor of outcome in critically ill septic patients?

Crit Care Med 2005; 33(11):2494-2500

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Sakka SG, Reinhart K, Meier-Hellmann A

Prognostic value of the indocyanine green plasma disappearance rate in critically ill patients

Chest 2002; 122(5):1715-20

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3.1.3 Surgical

Eryilmaz HB, Memis D, Sezer A, Inal M

The Effects of Different Insufflation Pressures on Liver Functions Assessed with LiMON on Patients Undergoing Laparoscopic Cholecystectomy

Scientific World Journal 2012: 172575

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Sakka SG

Indocyanine green plasma disappearance rate as an indicator of hepato-splanchnic ischemia during abdominal compartment syndrome

Anesth Analg 2007; 104(4):1003-4

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Poeze M, Ramsay G, Buuman WA, Greve JW, Dentener M, Takala J

Increased hepatosplanchnic inflammation precedes the development of organ dysfunction after elective high-risk surgery

Shock 2002; 17:451-8

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3.1.4 Medical

Zoller B, Spanaus K, Gerster R, Fasshauer M, Stehberger PA, Klinzing S, Vergopoulos A, von Eckardstein A, Bechir M

ICG-liver test versus new biomarkers as prognostic markers for prolonged length of stay in critically ill patients - a prospective study of accuracy for prediction of length of stay in the ICU

Ann Intensive Care 2014; 4: 19

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Quintero J, Miserachs M, Ortega J, Bueno J, Dopazo C, Bilbao I, Castells L, Charco R

Indocyanine green plasma disappearance rate: a new tool for the classification of paediatric patients with acute liver failure

Liver Int 2014; 34(5): 689-94

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Ameloot K, Meersseman P, Wilmer A, Hermans G, Gerits A, Spriet I, Wauters J

The influence of continuous venovenous renal replacement therapy on the plasma disappearance rate of indocyanine green

Intensive Care Med 2013; 39(12): 2231-2232

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Malbrain ML, Viaene D, Kortgen A, De Laet I, Dits H, Van Regenmortel N, Schoonheydt K, Bauer, M

Relationship between intra-abdominal pressure and indocyanine green plasma disappearance rate: hepatic perfusion may be impaired in critically ill patients with intra-abdominal hypertension

Ann Intensive Care 2012; 2 Suppl 1: S19

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Steinvall I, Fredrikson M, Bak Z, Sjoberg J

Incidence of early burn-induced effects on liver function as reflected by the plasma disappearance rate of indocyanine green: A prospective descriptive cohort study

Burns 2012; 38(2): 214-24

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Inal MT, Memis D, Sezer YA, Atalay M, Karakoc A, Sut N

Effects of intra-abdominal pressure on liver function assessed with the LiMON in critically ill patients

Can J Surg 2011; 54(2): 42709.

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Seibel A, Muller M, Sakka S

Indocyanine green plasma disappearance rate for monitoring hepatosplanchnic blood flow

Intensive Care Med 2011; 37(2): 357-9

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Sakka SG, Reinhart K, Meier-Hellmann A

Prognostic value of the indocyanine green plasma disappearance rate in critically ill patients

Chest 2002; 122(5):1715-20

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3.2 Liver Transplantation

Olmedilla L, Lisbona CJ, Perez-Pena JM, Lopez-Baena JA, Garutti I, Salcedo M, Sanz J, Tisner M, Asencio JM, Fernandez-Quero L, Banares R

Early Measurement of Indocyanine Green Clearance Accurately Predicts Short-Term Outcomes After Liver Transplantation

Transplantation 2015; epub

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Zarrinpar A, Lee C, Noguchi E, Yersiz H, Agopian VG, Kaldas FM, Farmer DG, Busuttill RW

A rapid, reproducible, noninvasive predictor of liver graft survival

J Surg Res 2015; 197(1): 183 - 90

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Vos JJ, Scheeren TW, Lukes DJ, de Boer MT, Hendriks HG, Wietasch JK

Intraoperative ICG plasma disappearance rate helps to predict absence of early postoperative complications after orthotopic liver transplantation

J Clin Monit Comput 2013; 27(5): 591-8

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Levesque E, Hoti E, Azoulay D, Adam R, Samuel D, Castaing D, Saliba F

Non-invasive ICG-clearance: a useful tool for the management of hepatic artery thrombosis following liver transplantation

Clin Transplant 2011; 25(2): 297-301

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Levesque E, Saliba F, Benhamida S, Ichai P, Azoulay D, Adam R, Castaing D, Samuel D

Plasma disappearance rate of indocyanine green: a tool to evaluate early graft outcome after liver transplantation

Liver Transpl 2009; 15(10): 1358-64

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Olmedilla L, Perez-Pena JM, Ripoll C, Garutti I, de Diego R, Salcedo M, Jimenez C, Banares R

Early noninvasive measurement of the indocyanine green plasma disappearance rate accurately predicts early graft dysfunction and mortality after deceased donor liver transplantation

Liver Transpl 2009; 15(10): 1247-53

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Parker BM, Cywinski JB, Alster JM, Irefin SA, Popovich M, Beven M, Fung JJ

Predicting immunosuppressant dosing in the early postoperative period with noninvasive indocyanine green elimination following orthotopic liver transplantation

Liver Transpl 2008; 14(1): 46-52

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Scheingraber S, Richter S, Igna D, Girndt M, Flesch S, Kleinschmidt S, Schilling MK

Indocyanine green elimination but not bilirubin indicates improvement of graft function during MARS therapy

Clin Transplant 2007; 21(6): p. 689-95

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Hori T, Iida T, Yagi S, Taniguchi K, Yamamoto C, Mizuno S, Yamagiwa K, Isaji S, Uemoto S

K(ICG) value, a reliable real-time estimator of graft function, accurately predicts outcomes in adult living-donor liver transplantation

Liver Transpl 2006; 12: 605-13

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Faybik P, Krenn CG, Baker A, Lahner D, Berlakovich G, Steltzer H, Hetz H

Comparison of invasive and noninvasive measurement of plasma disappearance rate of indocyanine green in patients undergoing liver transplantation: a prospective investigator-blinded study

Liver Transpl 2004; 10(8):1060-4

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von Spiegel T, Scholz M, Wietasch G, Hering R, Allen SJ, Wood P, Hoeft A

Perioperative monitoring of indocyanine green clearance and plasma disappearance rate in patients undergoing liver transplantation

Anaesthesist 2002; 51(5):359-66

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Mandell MS, Wachs M, Niemann CU, Henthorn TK

Elimination of indocyanine green in the perioperative evaluation of donor liver function

Anesth Analg 2002; 95(5):1182-4

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Niemann CU, Roberts JP, Ascher NL, Yost CS

Intraoperative hemodynamics and liver function in adult-to-adult living liver donors

Liver Transpl 2002; 8(12):1126-32

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Krenn CG, Schafer B, Berlakovich GA, Steininger R, Steltzer H, Spiss CK

Detection of graft nonfunction after liver transplantation by assessment of indocyanine green kinetics

Anesth Analg 1998 Jul;87(1):34-6

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Wesslau C, Krüger R, May G

Clinical investigations using indocyanine green clearance for evaluation of liver function in organ donors

Transplantology 1994; 5(1):7-9

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3.3 Liver Surgery / Resection

Thomas MN, Weninger E, Angele M, Bosch F, Pratschke S, Andrassy J, Rentsch M, Stangl M, Hartwig W, Werner J, Guba M

Intraoperative simulation of remnant liver function during anatomic liver resection with indocyanine green clearance (LiMON) measurements

HPB (Oxford) 2015; 17(6): 471 - 6

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Tralhao JG, Hoti E, Oliveiros B, Botelho MF, Sousa FC

Study of perioperative liver function by dynamic monitoring of ICG-clearance

Hepatogastroenterology 2012; 59(116): 1179-83

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de Liguori Carino N, O'Reilly DA, Dajani K, Ghaneh P, Poston GJ, Wu AV

Perioperative use of the LiMON method of indocyanine green elimination measurement for the prediction and early detection of post-hepatectomy liver failure

Eur J Surg Oncol 2009; 35(9):957-62

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Szjarto A, Hargitai B, Fischer S, Darvas K, Kupcsulik P

Two-staged procedure of portal ligation and hepatectomy monitored by ICG clearance

J Invest Surg 2009; 22(1): 63-8

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Scheingraber S, Richter S, Igna D, Flesch S, Kopp B, Schilling MK

Indocyanine green disappearance rate is the most useful marker for liver resection

Hepatogastroenterology 2008; 55(85): 1394-9

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Akita H, Sasaki Y, Yamada T, Gotoh K, Ohigashi H, Eguchi H, Yano M, Ishikawa O, Imaoka S

Real-Time Intraoperative Assessment of Residual Liver Functional Reserve Using Pulse Dye Densitometry.

World J Surg 2008; 32(21): 2668-74

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Sato S, Miyake T, Mishiro T, Furuta K, Azumi T, Oshima N, Takahashi Y, Rumi MA, Ishihara S, Adachi K, Amano Y, Kinoshita Y

Kinetics of indocyanine green removal from blood can be used to predict the size of the area removed by radiofrequency ablation of hepatic nodules

J Gastroenterol Hepatol 2006; 21:1714-9

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Imamura H, Sano K, Sugawara Y, Kokudo N, Makuuchi M

Assessment of hepatic reserve for indication of hepatic resection: decision tree incorporating indocyanine green test

J Hepatobiliary Pancreat Surg 2005; 12: 16-22

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Lee SG, Hwang S

How I do it: assessment of hepatic functional reserve for indication of hepatic resection

J Hepatobiliary Pancreat Surg 2005; 12: 38-43

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Imamura H, Seyama Y, Kokudo N, Maema A, Sugawara Y, Sano K, Takayama T, Makuuchi M

One thousand fifty-six hepatectomies without mortality in 8 years

Arch Surg 2003; 138: 1198-1206

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Thasler WE, Bein T, Jauch KW

Perioperative effects of hepatic resection surgery on hemodynamics, pulmonary fluid balance, and indocyanine green clearance

Langenbecks Arch Surg 2002; 387: 271-5

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Ishikawa M, Yogita S, Miyake H, Fukuda Y, Harada M, Wada D, Tashiro S

Clarification of risk factors for hepatectomy in patients with hepatocellular carcinoma

Hepatogastroenterology 2002; 49: 1625-31

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Eguchi H, Umeshita K, Sakon M, Nagano H, Ito Y, Kishimoto SI, Dono K, Nakamori S, Takeda T, Gotoh M, Wakasa K, Matsuura N, Monden M

Presence of active hepatitis associated with liver cirrhosis is a risk factor for mortality caused by posthepatectomy liver failure

Dig Dis Sci 2000; 45: 1383-8

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Hsia CY, Lui WY, Chau GY, King KL, Loong CC, Wu CW

Perioperative safety and prognosis in hepatocellular carcinoma patients with impaired liver function

J Am Coll Surg 2000; 190: 574-9

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Hanazaki K, Kajikawa S, Shimozawa N, Mihara M, Shimada K, Hiraguri M, Koide N, Adachi W, Amano J

Survival and recurrence after hepatic resection of 386 consecutive patients with hepatocellular carcinoma

J Am Coll Surg 2000; 191: 381-8

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3.4 Hepatology / Gastroenterology

Horvatits T, Kneidinger N, Drolz A, Roedl K, Rutter K, Kluge S, Trauner M, Fuhrmann V

Prognostic impact of ICG-PDR in patients with hypoxic hepatitis

Ann Intensive Care 5(1): 47

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Levesque E, Martin E, Dudau D, Lim C, Dhonneur G, Azoulay D

Current use and perspective of indocyanine green clearance in liver diseases

Anaesth Crit Care Pain Med 2015; epub

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Zipprich A, Kuss O, Rogowski S, Kleber G, Lotterer E, Seufferlein T, Fleig WE, Dollinger MM

Incorporating indocyanin green clearance into the Model for End Stage Liver Disease (MELD-ICG) improves prognostic accuracy in intermediate to advanced cirrhosis

Gut 2010; 59(7): 963-8

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Merle U, Sieg O, Stremmel W, Encke J, Eisenbach C

Sensitivity and specificity of plasma disappearance rate of indocyanine green as a prognostic indicator in acute liver failure

BMC Gastroenterol 2009; 9: 91

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Herold C, Heinz R, Radespiel-Tröger M, Schneider HT, Schuppan D, Hahn EG

Quantitative testing of liver function in patients with cirrhosis due to chronic hepatitis C to assess disease severity.

Liver. 2001; 21(1):26-30

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3.5 Hypovolemic Shock

Ribitsch W, Schneditz D, Franssen CF, Schilcher G, Stadlbauer V, Horina JH, Rosenkranz AR

Increased Hepato-Splanchnic Vasoconstriction in Diabetics during Regular Hemodialysis

PLoS One 2015; 10(12): e0145411

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Kisch H, Leucht S, Lichtwarck-Aschoff M, Pfeiffer UJ

Accuracy and reproducibility of the measurement of actively circulating blood volume with an integrated fiberoptic monitoring system.

Crit Care Med. 1995; 23(5):885-93

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4 MONITORING THERAPEUTIC EFFECTS

4.1 Drug Therapies

4.1.1 Septic Shock

Bicakcioglu M, Aydogan MS, Sayan H, Toprak HI, Isik B, Yilmaz S, Yologlu S

Effects of different positive end-expiratory pressure values on liver function and indocyanine green clearance test in liver transplantation donors: a prospective, randomized, double-blind study

Transplant Proc 2015; 47(4): 1190-3

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Sayan H, Aydogan MS, Bicakcioglu M, Toprak HI, Isik B, Yilmaz S

Effects of Thoracic Epidural Anesthesia on Liver Blood Flow and Indocyanine Green Clearance Test in Living-Donor Liver Transplantation: A Prospective, Randomized, Double-Blind Study

Transplant Proc 2015; 47(5): 1462-5

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Lehmann C, Taymoorian K, Wauer H, Krausch D, Birnbaum J, Kox WJ

Effects of the stable prostacyclin analogue iloprost on the plasma disappearance rate of indocyanine green in human septic shock

Intensive Care Med. 2000; 26(10):1557-60

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Meier-Hellmann A, Bredle DL, Specht M, Hannemann L, Reinhart K

Dopexamine increases splanchnic blood flow but decreases gastric mucosal pH in severe septic patients treated with dobutamine

Crit Care Med 1999; 27: 2166-71

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Joly LM, Monchi M, Cariou A, Chiche JD, Bellenfant F, Brunet F, Dhainaut JF

Effects of dobutamine on gastric mucosal perfusion and hepatic metabolism in patients with septic shock

Am J Respir Crit Care Med 1999; 160: 1983-6

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4.1.2 Liver Surgery / Dysfunction

Sheng QS, Lang R, He Q, Yang YJ, Zhao DF, Chen DZ

Indocyanine green clearance test and model for end-stage liver disease score of patients with liver cirrhosis.

Hepatobiliary Pancreat Dis Int 2009; 8(1): 46-9

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Orii R, Sugawara Y, Hayashida M, Yamada Y, Chang K, Takayama T, Makuuchi M, Hanaoka K
Effects of amrinone on ischaemia-reperfusion injury in cirrhotic patients undergoing hepatectomy: a comparative study with prostaglandin E1.
Br J Anaesth. 2000; 85(3):389-95

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Devlin J, Ellis AE, McPeake J, Heaton N, Wendon JA, Williams R
N-acetylcysteine improves indocyanine green extraction and oxygen transport during hepatic dysfunction.
Crit Care Med. 1997; 25(2):236-42

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4.1.3 Adjuvant Therapies

Memis D, Inal MT, Sut N

The effects of levosimendan vs dobutamine added to dopamine on liver functions assessed with noninvasive liver function monitoring in patients with septic shock

J Crit Care 2012; 27(3): 318.e1-6

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Abraldes J, Albillos A, Banares R, Turnes J, Gonzalez R, Garcia-Pagan J, Bosch J

Simvastatin Lowers Portal Pressure in Patients with Cirrhosis and Portal Hypertension: a Randomized Controlled Trial.

Gastroenterology 2009; 136(5): 1651-8

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Link A, Girndt M, Selejan S, Mathes A, Bohm M, Rensing H

Argatroban for anticoagulation in continuous renal replacement therapy.

Crit Care Med 2009; 37(1): 105-10.

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