

Reproductive Endocrinology and Infertility

Douglas T. Carrell · C. Matthew Peterson
Editors

Reproductive Endocrinology and Infertility

Integrating Modern Clinical
and Laboratory Practice

 Springer

Editors

Douglas T. Carrell, PhD, H.C.L.D.
Professor of Surgery (Urology),
Obstetrics and Gynecology and Physiology
University of Utah School of Medicine
Director of IVF and Andrology Laboratories
Salt Lake City, Utah 84132, US
douglas.carrell@hsc.utah.edu

C. Matthew Peterson, MD
John A. Dixon Presidential Professor and Chair
Department of Obstetrics and Gynecology
University of Utah School of Medicine
Practice Director
Utah Center for Reproductive Medicine
Salt Lake City, UT
c.matthew.peterson@hsc.utah.edu

ISBN 978-1-4419-1435-4 e-ISBN 978-1-4419-1436-1
DOI 10.1007/978-1-4419-1436-1
Springer New York Dordrecht Heidelberg London

Library of Congress Control Number: 2010922889

© Springer Science+Business Media, LLC 2010

All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Springer Science+Business Media, LLC, 233 Spring Street, New York, NY 10013, USA), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden.

The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

We dedicate this book to our mentors, students, residents, and fellows who have continually refreshed our excitement for reproductive medicine as we learn with them, and to our families who have sacrificed much to assist us in our professions.

Preface

More than 30 years after the birth of Louise Brown, the first child born as a result of in vitro fertilization, the practice of reproductive medicine has grown and evolved in a dramatic and profound fashion. Classical reproductive endocrinology and surgery remain important components of clinical practice, but they are joined with major developments in the laboratory and clinic that have opened the doors of therapy to millions. Furthermore, the outlook for the future is stunning, including novel technologies that may facilitate quantum advances in the clinic and laboratory.

The advances made in the treatment of infertility have made the care of infertile patients more successful, rewarding, and exciting. However, management of the modern reproductive endocrinology and infertility clinic has become very complex. In addition to the medical and scientific knowledge necessary to manage a clinic and laboratory, the modern director must have an understanding of such disparate fields as marketing, accounting, management, and regulatory issues. It is impractical to obtain such a broad range of experience during a doctoral or fellowship program and difficult to follow the advances of each field through traditional methods. This book was developed to assist the practicing reproductive endocrinologist and/or laboratory director by providing an overview of relevant scientific, medical, and management issues in a single volume. While no book can cover everything associated with managing a reproductive endocrinology clinic and laboratory, we have enlisted experts from all relevant areas to provide concise, practical, and evidence based summaries of relevant topics. It is our hope that this resource will be of assistance to physicians and scientists engaged in this exciting field of medicine.

Salt Lake City, UT
Salt Lake City, UT

Douglas T. Carrell, Ph.D., H.C.L.D
C. Matthew Peterson, M.D

Contents

Part I Management of the R.E.I. Clinic and Laboratories

- 1 Characteristics of a Successful R.E.I. Clinic and Laboratory** 3
Douglas T. Carrell and C. Matthew Peterson
- 2 Assisted Reproductive Technology Practice Management**..... 7
C. Matthew Peterson, Ahmad O. Hammoud, Erika Lindley,
Douglas T. Carrell, and Karen Wilson
- 3 Collaboration Within the Reproductive Endocrinology
and Infertility Practice: Integration of Laboratory
and Clinic Operations**..... 39
Vincent W. Aoki and Douglas T. Carrell
- 4 Informed Consent in Advanced Reproductive Technology** 43
Kirtly Parker Jones
- 5 Reproductive Laboratory Regulations, Certifications and
Reporting Systems** 55
Brooks A. Keel and Tammie K. Schalue
- 6 Successfully Integrating the FDA Regulations into Your Practice** 71
Wendy D. Latash
- 7 Psychosocial Consequences of Infertility and Treatment**..... 93
Lone Schmidt
- 8 A Live Baby or Your Money Back: The Marketing of In Vitro
Fertilization Procedures** 101
David C. Schmittlein and Donald G. Morrison

Part II Female Reproductive Physiology and Medicine

- 9 Ovulation: A Molecular View**..... 119
Mats Brännström, Anna Karin Lind, and Pernilla Dahm-Kähler
- 10 Clinical Evaluation of Female Factor Infertility** 133
Yulian Zhao, Lisa Kolp, Melissa Yates, and Howard Zacur
- 11 Polycystic Ovary Syndrome** 147
Catherine J. Wheeler, William R. Keye, and C. Matthew Peterson
- 12 The Current Status for Metformin Use in Reproductive Medicine** 183
Richard S. Legro
- 13 Clinical Aspects of Endometriosis** 191
Attila Bokor, Christel Meuleman, and Thomas D’Hooghe

14	Common Endocrinopathies in Reproductive Endocrinology	209
	Shawn Gurtcheff and C. Matthew Peterson	
15	Acquired Uterine Factors and Infertility	235
	Harry H. Hatasaka	
16	Müllerian (Paramesonephric) Anomalies and Associated Wolffian (Mesonephric) Duct Malformations	265
	Jessie Dorais and C. Matthew Peterson	
17	Recurrent Miscarriage	281
	D. Ware Branch and Cara Heuser	
18	Laparoscopy in the Diagnosis and Treatment of Female Infertility	297
	Howard T. Sharp and Johnny Yi	
19	Turner Syndrome	307
	Carolyn A. Bondy	
20	Errors in Chromosome Segregation During Oogenesis and Early Embryogenesis	325
	Maj Hultén, Edward Smith, and Joy Delhanty	
Part III Male Reproductive Physiology and Medicine		
21	An Overview of Sperm Production	345
	Louis Hermo and Bernard Robaire	
22	Meiotic Recombination and Errors During Spermatogenesis	357
	Helen Ghislaine Tempest and Renee Halo Martin	
23	Clinical Evaluation and Treatment of Male Factor Infertility	367
	Michael A. Poch and Mark Sigman	
24	Semen Analysis: Essentials for the Clinician	379
	Lars Björndahl	
25	Sperm Capacitation, the Acrosome Reaction, and Fertilization	389
	Peter Sutovsky	
26	Advanced Tests of Sperm Function	423
	Joseph P. Alukal and Dolores J. Lamb	
27	Genetic Testing of Male Infertility	431
	Csilla Krausz	
28	Varicocele and Male Infertility	445
	Cigdem Tanrikut and Peter N. Schlegel	
29	Sperm Retrieval Techniques	453
	Paul J. Turek	
30	The Clinical Utility of the Evaluation of Sperm Chromatin	467
	Sergey I. Moskvovtsev and Brendan M. Mullen	
Part IV Assisted Reproductive Therapies: Artificial Insemination		
31	Artificial Insemination: Intrauterine Insemination	487
	Pieterneel Steures, Ben W.J. Mol, and Fulco van der Veen	
32	Sperm Preparation for Artificial Insemination	497
	Greg L. Christensen	

33 Sperm Banking, Donation, and Transport in the Age of Assisted Reproduction: Federal and State Regulation	509
Grace M. Centola	
34 Reproductive Treatment of HIV-1 Discordant Couples	517
Valeria Savasi and Enrico Ferrazzi	
35 Ovulation Induction	525
Mark Gibson	
36 Transvaginal Sonography in Reproductive Endocrinology and Infertility	545
Anne Kennedy and C. Matthew Peterson	
Part V Assisted Reproductive Therapy: In Vitro Fertilization	
37 Establishing the IVF Laboratory: A Systems View	569
Antonia V. Gilligan	
38 Preparation and Selection of Sperm for IVF and ICSI	579
Charles L. Bormann, Jose R. Alagretti, Eduardo L.A. da Motta, Paulo Serafini, and Gary D. Smith	
39 The Genetic and Epigenetic Contributions of Sperm to Early Embryogenesis	591
Denny Sakkas, Maria Lalioti, Hasan M. El-Fakahany, and Emre Seli	
40 Micromanipulation of Human Oocytes and Embryos: Applications of Intracytoplasmic Sperm Injection and Assisted Hatching in Infertility Treatment	601
Kenneth I. Aston and Klaus E. Weimer	
41 Embryo Culture Techniques	613
Katharine V. Jackson and Catherine Racowsky	
42 In-Vitro Maturation of Human Oocytes	633
Ezgi Demirtas, Hananel Holzer, Weon-Young SON, Ri-Cheng Chain, and Seang Lin Tan	
43 Integrating Preimplantation Genetic Diagnosis into the ART Laboratory	647
Kenneth C. Drury	
44 Evaluation and Selection of Preimplantation Embryos for Transfer	663
Lynette Scott	
45 Embryo Transfer in IVF: Evidence-Based Clinical Practice	677
Lindsay Mains and Bradley J. Van Voorhis	
46 Cryopreservation of Human Oocytes and Embryos	689
Barry Behr and Yimin Shu	
47 Preserving Fertility	703
Kutluk Oktay and Ozgur Oktem	
48 Ovarian Hyperstimulation Syndrome	711
Kenneth H.H. Wong	
49 Pregnancy Outcomes in Infertile Couples	715
Caroline Signore and Uma M. Reddy	

50	The Impact of Complementary Medicine on In Vitro Fertilization	727
	Laurence C. Udoff and Grant Zhang	
Part VI Research in the REI Practice and Laboratories		
51	Designing a Clinical Research Infrastructure	741
	Tonya Edvalson, Emily Hixson, and Michael Varner	
52	Integrating Research into a Clinical Practice.....	751
	Douglas T. Carrell	
53	Research Regulations: The Role of the Institutional Review Board	757
	Benjamin R. Emery and Mark A. Munger	
54	Technology Transfer and Its Role in the Practice of Reproductive Endocrinology and Infertility	763
	Ashley J. Stevens	
55	The Environment and Reproduction: Endocrine Disruption, Reproductive Impairment, and Epigenetics	781
	C. Matthew Peterson, Douglas T. Carrell, Michael Varner, Joseph Stanford, Mary Croughan, and Germaine Buck Louis	
Index.....		805

Contributors

Jose R. Alagretti, BS

Huntington Center for Reproductive medicine of Brazil, Sao Paulo, Brazil

Joseph P. Alukal, MD

Scott Department of Urology, Baylor College of Medicine, Houston, TX, USA

Vincent W. Aoki, PhD

Eastside Fertility Laboratory, Bellevue, WA, USA

Kenneth I. Aston, PhD

Department of Urology, University of Utah School of Medicine, Salt Lake City, UT, USA

Barry Behr, PhD

Department of Obstetrics & Gynecology, Stanford University, Palo Alto, CA, USA

Lars Bjorndahl, MD, PhD

Center for Andrology and Sexual Medicine, Endocrinology Clinic Karolinska University Hospital, Huddinge and Department of Medicine, Huddinge, Karol inska Institutet, Stockholm, Sweden

Attila Bokor, MD

Leuven University Fertility Center, UZ Gasthuisberg, K.U.Leuven, Belgium

Carolyn A. Bondy, MD

Developmental Endocrinology Branch, National Institute of Child Health and Human Development, National Institutes of Health, Bethesda, MD, USA

Charles L. Bormann, PhD

Departments of Obstetrics and Gynecology and Urology, University of Michigan, Ann Arbor, MI, USA

D. Ware Branch, MD

Division of Maternal Fetal Medicine, Department of Obstetrics and Gynecology, University of Utah School of Medicine, Salt Lake City, UT, USA

Mats Brännström, MD, PhD

Department of Obstetrics and Gynecology, Sahlgrenska Academy at Göteborg University, Göteborg, Sweden

Douglas T. Carrell, PhD

Departments of Surgery (Urology), Obstetrics and Gynecology, and Physiology, University of Utah School of Medicine, Salt Lake City, Utah 84132, US

Grace M. Centola, PhD

LifeCell DX, Inc., Buffalo, NY, USA

New England Cryogenic Center, Newton, MA, USA

Ri-Cheng Chain, PhD

Department of Obstetrics and Gynecology, Royal Victoria Hospital Women's Pavilion,
McGill University, Montreal, QC, Canada

Greg L. Christensen, PhD

The Fertility Center at University Women's Healthcare, University of Louisville,
Louisville, KY, USA

Mary Croughan, PhD

Departments of Obstetrics, Gynecology, Reproductive Sciences, and Epidemiology
and Biostatistics, University of California, San Francisco, CA, USA

Pernilla Dahm-Kähler, MD, PhD

Department of Obstetrics and Gynecology, Sahlgrenska Academy at Göteborg University,
Göteborg, Sweden

Eduardo L.A. da Motta, MD

Huntington Center for Reproductive Medicine of Brazil, Sao Paulo, Brazil

Joy Delhanty, PhD

UCL Center for Obstetrics & Gynecology, University College London,
Gower Street, London, England

Ezgi Demirtas, MD

Department of Obstetrics and Gynecology, Royal Victoria Hospital Women's Pavilion,
McGill University, Montreal, QC, Canada

Thomas M. D'Hooghe, MD, PhD

Leuven University Fertility Center, UZ Gasthuisberg, K.U. Leuven, Belgium

Jessie Dorais, MD

Department of Obstetrics and Gynecology, University of Utah School of Medicine,
Salt Lake City, UT, USA

Kenneth C. Drury, PhD

Department of Obstetrics and Gynecology, University of Florida College of Medicine,
Gainesville, FL, USA

Tonya Edvalson

Department of Obstetrics and Gynecology, University of Utah School of Medicine,
Salt Lake City, UT, USA

Hasan M. El-Fakahanya, MD

Department of Obstetrics, Gynecology and Reproductive Sciences,
Yale University School of Medicine, New Haven, CT, USA

Benjamin R. Emery, MPhil

Department of Urology, Andrology & IVF Laboratories,
University of Utah School of Medicine, Salt Lake City, UT, USA

Enrico Ferrazzi, MD

Department of Obstetrics and Gynecology, Sacco Clinical Sciences Institute,
University of Milan Medical School, Milan, Italy

Mark Gibson, MD

Department of Obstetrics & Gynecology, University Center for Reproductive Medicine,
University of Utah School of Medicine, Salt Lake City, UT, USA

Antonia V. Gilligan

Alpha Environmental, Inc. Emerson, NJ, USA

Shawn Gurtcheff, MD

Department of Obstetrics & Gynecology, Utah Center for Reproductive Medicine,
University of Utah School of Medicine, Salt Lake City, UT, USA

Ahmad O. Hammoud, MD

Department of Obstetrics & Gynecology, Utah Center for Reproductive Medicine,
University of Utah School of Medicine, Salt Lake City, UT, USA

Harry H. Hatasaka, MD

Department of Obstetrics & Gynecology, Utah Center for Reproductive Medicine,
University of Utah School of Medicine, Salt Lake City, UT, USA

Louis Hermo, PhD

Departments of Anatomy & Cell Biology, McGill University, Montreal, QC, Canada

Cara Heuser, MD

Division of Maternal Fetal Medicine, Department of Obstetrics and Gynecology,
University of Utah School of Medicine, Salt Lake City, UT, USA

Emily Hixson, MBA

Department of Obstetrics and Gynecology, University of Utah School of Medicine,
Salt Lake City, UT, USA

Hananel Holzer, MD, BSc

Department of Obstetrics and Gynecology, Royal Victoria Hospital Women's Pavilion,
McGill University, Montreal, QC, Canada

Maj Hultén, MD, PhD

Warwick Medical School, University of Warwick, Coventry, England

Katharine V. Jackson, BS, ELD

Department of Obstetrics, Gynecology and Reproductive Biology,
Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA

Kirtly Parker Jones, MD

Department of Obstetrics & Gynecology, Utah Center for Reproductive Medicine,
University of Utah School of Medicine, Salt Lake City, UT, USA

Brooks A. Keel, PhD

Departments of Biological Sciences and Research and Economic Development,
Louisiana State University, Baton Rouge, LA, USA

Anne Kennedy, MD

Department of Radiology, Health Sciences Center, University of Utah,
Salt Lake City, UT, USA

William R. Keye, MD

Department of Obstetrics and Gynecology, Utah Center for Reproductive Medicine,
University of Utah School of Medicine, Salt Lake City, UT, USA

Lisa Kolp, MD

Department of Obstetrics and Gynecology, Johns Hopkins Medicine,
Johns Hopkins at Green Spring Station, Lutherville, MD, USA

Csilla Krausz, MD, PhD

Andrology Unit, Department of Clinical Physipathology, University of Florence,
Florence, Italy

Maria Lalioti, MD

Department of Obstetrics, Gynecology and Reproductive Sciences, Yale University School
of Medicine, New Haven, CT, USA

Dolores J. Lamb, PhD

Scott Department of Urology, Baylor College of Medicine, Houston, TX, USA

Wendy D. Latash, PhD

Jade Tree Solutions, LLC, Northbrook, IL, USA

Richard S. Legro, MD

Department of Obstetrics and Gynecology, Penn State College of Medicine,
M.S. Hershey Medical Center, Hershey, PA, USA

Anna Karin Lind, MD, PhD

Department of Obstetrics and Gynecology, Sahlgrenska Academy at Göteborg University,
Göteborg, Sweden

Erika Lindley, MBA

Department of Obstetrics & Gynecology, University of Utah School of Medicine, Salt Lake
City, UT, USA

Germaine Buck Louis, PhD, MS

Epidemiology Branch, Division of Epidemiology, Statistics, and Prevention Research,
Eunice Kennedy Shriver National Institute of Child Health and Human Development,
Bethesda, MD, USA

Lindsay Mains, MD

Department of Obstetrics and Gynecology, University of Iowa, Iowa City, IA, USA

Renée Halo Martin, PhD

Department of Medical Genetics, University of Calgary, Calgary, AB, Canada

Christel Meuleman, MD

Department of Obstetrics and Gynecology, Leuven University Fertility Center,
UZ Gasthuisberg, K.U. Leuven, Belgium

Ben W.J. Mol, MD, PhD

Center for Reproductive Medicine, Academic Medical Center, Amsterdam, The Netherlands

Donald G. Morrison, PhD

Anderson Graduate School of Management, University of California at Los Angeles,
Los Angeles, CA, USA

Sergey I. Moskovtsev, MD, PhD

Andrology Laboratory, Department of Pathology and Laboratory Medicine,
Mount Sinai Hospital, Toronto, ON, Canada

Brendan M. Mullen, MD

Andrology Laboratory, Department of Pathology and Laboratory Medicine,
Mount Sinai Hospital, Toronto, ON, Canada

Mark A. Munger, PharmD

Department of Pharmacology, University of Utah College of Pharmacy, Salt Lake
City, UT, USA

Kutluk Oktay, MD

Department of Obstetrics & Gynecology, New York Medical College-Westchester
Medical Center, Valhalla, NY, USA
The Institute for Fertility Preservation, Center for Human Reproduction, New York, NY, USA

Ozgur Oktem, MD

Department of Obstetrics & Gynecology, New York Medical College-Westchester Medical
Center, Valhalla, NY, USA
The Institute for Fertility Preservation, Center for Human Reproduction, New York, NY, USA

C. Matthew Peterson, MD

Department of Obstetrics & Gynecology, Utah Center for Reproductive Medicine,
University of Utah School of Medicine, Salt Lake City, UT, USA

Michael A. Poch, MD

Department of Urology, Brown University, Providence, RI, USA

Catherine Racowsky, PhD

Department of Obstetrics, Gynecology and Reproductive Biology, Brigham and Women's
Hospital and Harvard Medical School Boston, MA, USA

Uma M. Reddy, MD, MPH

Pregnancy and Perinatology Branch, Department of Health and Human Services,
Eunice Kennedy Shriver National Institute of Child Health and Human Development,
NIH, Bethesda, MD, USA

Bernard Robaire, PhD

Department of Pharmacology & Therapeutics and Obstetrics & Gynecology,
McGill University, Montreal, QC, Canada

Denny Sakkas, PhD

Department of Obstetrics, Gynecology and Reproductive Sciences,
Yale University School of Medicine, New Haven, CT, USA

Valeria Savasi, MD, PhD

Department of Obstetrics and Gynecology, Sacco Clinical Sciences Institute,
University of Milan Medical School, Milan, Italy

Tammie K. Schalue, PhD

Birenbaum and Associates, St. Louis, MO, USA

Peter N. Schlegel, MD

Departments of Urology and Reproductive Medicine, Weill Medical College of Cornell
University, New York, NY, USA

Lone Schmidt, MD, DMSci, PhD

Institute of Public Health, University of Copenhagen, Copenhagen, Denmark

David C. Schmittlein, PhD, MPH

Massachusetts Institute of Technology Sloan School of Management, Cambridge, MA, USA

Lynette Scott, PhD

Fertility Centers of New England, Reading, MA, USA

Emre Seli, MD

Department of Obstetrics, Gynecology and Reproductive Sciences,
Yale University School of Medicine, New Haven, CT, USA

Paulo Serafini, MD

Huntington Center for Reproductive Medicine of Brazil, Sao Paulo, Brazil

Mark Sigman, MD

Department of Urology, Brown University, Providence, RI, USA

Caroline Signore, MD, MPH

Pregnancy and Perinatology Branch, Department of Health and Human Services,
National Institute of Child Health and Human Development, NIH,
Bethesda, MD, USA

Howard T. Sharp, MD

Division of General Gynecology, Department of Obstetrics & Gynecology,
University of Utah School of Medicine, Salt Lake City, UT, USA

Yimin Shu, MD, PhD

Stanford Fertility and Reproductive Medicine Center, Palo Alto, CA, USA

Edward Smith, PhD

Department of Biological Sciences, University of Warwick, Coventry, England

Gary D. Smith, PhD

Departments of Obstetrics and Gynecology, Molecular and Integrative Physiology, Urology, and Reproductive Sciences Program, University of Michigan, Ann Arbor, MI, USA

Weon-Young Son, PhD

Department of Obstetrics and Gynecology, Royal Victoria Hospital Women's Pavilion, McGill University, Montreal, QC, Canada

Joseph Stanford, MD, MPH

Department of Family and Preventive Medicine, University of Utah Health Sciences Center, Salt Lake City, UT, USA

Pieterneel Steures, MD

Center for Reproductive Medicine, Academic Medical Center, Amsterdam, The Netherlands

Ashley J. Stevens, DPhil

Institute for Technology Entrepreneurship and Commercialization School of Management and Technology Transfer, Boston University, Boston, MA, USA

Peter Sutovsky, PhD

Animal Science and Clinical Obstetrics & Gynecology, Section Editor for Reproductive Biology, Cell & Tissue Research, University of Missouri-Columbia, Columbia, MO, USA

Seang Lin Tan, MD, MBBS, FRCOG, FRCSC, MMed (O&G), MBA

Department of Obstetrics and Gynecology, Royal Victoria Hospital Women's Pavilion, McGill University, Montreal, QC, Canada

Cigdem Tanrikut, MD

Massachusetts General Hospital Fertility Center, Massachusetts General Hospital, Boston, MA, USA

Helen Ghislaine Tempest, PhD

Department of Medical Genetics, University of Calgary, Calgary, AB, Canada

Paul J. Turek, MD

Department of Urology, University of California San Francisco, San Francisco, CA, USA

Laurence C. Udoff, MD

Department of Obstetrics, Gynecology and Reproductive Sciences, University of Maryland School of Medicine, Baltimore, MD, USA

Fulco van der Veen, MD, PhD

Center for Reproductive Medicine, Academic Medical Center, Amsterdam, The Netherlands

Bradley J. Van Voorhis, MD

Department of Obstetrics and Gynecology, University of Iowa, Iowa City, IA, USA

Michael Varner, MD

Department of Obstetrics and Gynecology, University of Utah school of Medicine, Salt Lake City, UT, USA

Catherine J. Wheeler, MD

Department of Obstetrics and Gynecology, University of Utah School of Medicine, Salt Lake City, UT, USA

Klaus E. Wiemer, PhD

Northwest Center for Reproductive Sciences, Kirkland, WA, USA

Karen Wilson, MA

University Medical Billing and University Health Care Compliance,
University of Utah School of Medicine, Salt Lake City, UT

Kenneth H.H. Wong, MD, MBA

Loma Linda University Medical Center, Southern California Permanente Medical Group,
Loma Linda, CA, USA

Melissa Yates, MD

Department of Obstetrics and Gynecology, Johns Hopkins Medicine,
Johns Hopkins at Green Spring Station, Lutherville, MD, USA

Johnny Yi, MD

Division of General Gynecology, Department of Obstetrics & Gynecology,
University of Utah School of Medicine, Salt Lake City, UT, USA

Howard Zacur, MD, PhD

Department of Obstetrics and Gynecology, Johns Hopkins Medicine,
Johns Hopkins at Green Spring Station, Lutherville, MD, USA

Grant Zhang, PhD

Center for Integrative Medicine, University of Maryland School of Medicine,
Baltimore, MD, USA

Yulian Zhao, PhD, MD, MBA

Department of Obstetrics and Gynecology, Johns Hopkins Medicine,
Johns Hopkins at Green Spring Station, Lutherville, MD, USA