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(a) (b) Figure 10.2 The da Vinci Xi system: (a) surgeon console; (b) da Vinci Xi robot; (c) vision cart (courtesy of Intuitive Surgical).

Surgical robots have been considered to offer many benefits, which have arisen as a result of new technology in lenses, cameras and computer software. Just as laparoscopic surgery benefited from advances in light technology allowing the targeted transmission of light down tubing, robotic surgery benefits from computer integration of mechanical (surgical) arms that have paved the way for computer-integrated surgery. Vision Modern robotic camera systems offer 3D high-definition

imaging, providing stereoscopic vision with true depth perception that enhances the visualisation of tissue planes and key structures. Multiport systems typically employ a rigid endoscope with or without angulation. As with conventional endoscopes, angulation to 30° allows for a wider range of vision through manipulation of the camera position, which, in the case of robotic surgery, can be controlled by the surgeon at the console or, if required, by the assistant at the bedside. A reference horizon is commonly provided to the surgeon at the console system so as to maintain orientation throughout the procedure. More recently, modern single-port systems such as the da Vinci SP employ a wristed camera system that, in combination with fully wristed instruments, may allow for operative triangulation while at the same time maintaining a small, single skin incision.

Manoeuvrability, motion scaling and tremor suppression Improved manoeuvring as a result of the 'robotic wrist' in some systems allows for up to seven degrees of freedom, thus improving dexterity for the surgeon. This has particular benefits in fields with significant space restraints such as transoral surgery, where conventional laparoscopy has limited applicability. Furthermore, the increased dexterity of surgical robots may facilitate a minimal access approach to more complex procedures where the technical difficulty of applying conventional laparoscopy may be prohibitive. As the motion of the surgeon's hand is translated to the 'slave' motion of the robotic arm, modern surgical robots are able to scale down large external movements of the surgical hands to limited internal movements. At the same time, the computer may filter out tremor in the surgeon's hands, thus ensuring stability of the instrument tips and enhancing surgical precision.

Ergonomics Although the advent of straight stick laparoscopic surgery had many advantages for the patient, for the surgeon there was a trade-off in terms of operative ergonomics. Increased operative time in addition to unergonomic positioning can result in significant physical discomfort for the surgeon. This is particularly true in specialties such as bariatric surgery, where the patient's body habitus and the use of long, fulcrumed instruments puts further strain on the surgeon's back, neck and upper arms. The advent of robotic surgery vastly improves upon the ergonomic environment for the surgeon; in the case of many of the current master-slave systems, allowing for the surgeon to be seated at a console remote from the operating table (Figure 10.3). The console positioning can be optimised to reduce physical stress and fatigue. The enclosed console system of many robotic systems also provides the advantage of surgical isolation from external distractions that may impact on the operator's concentration. The disadvantage is reduced awareness of non-verbal communication, thus highlighting the importance of team training and regular verbal cues.

Motion compensation Although not commonplace in current clinical practice, robotic surgical systems may in future provide motion compensation - to facilitate surgery on a moving target. Examples where this may be beneficial are in beating heart cardiac surgery, such as coronary artery bypass grafting and mitral valve repair. In this setting, the increased dexterity of robotic surgery combined with removing the need for cardioplegia and cross-clamping may be particularly beneficial in terms of reducing the post-operative inflammatory response and improving its associated morbidity.

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