Table 1. Study Characteristics[a]

First Author, Year	Location	Device	Study Design	No. of Patients	Patient Age, Years	% Men	Race/ Ethnicity (%)	Indication for LVAD (%)	Duration of Support	Inclusion Criteria	Exclusion Criteria
Miller et al, 2007[46]	Multi-center	HeartMate II	Prospec-tive, observa-tional	133	50.1	76.0	White (69) African American (23)	BTT (100) ICM (37)	126 d, median	End-stage heart failure	Severe renal, pulmonary, or hepatic dysfunction; active, uncontrolled infection; mechanical aortic valve; aortic insufficiency; other support device (except IABP)
Schulman et al, 2007 [24]	New York, USA	HeartMate II, DeBakey Micro-Med	Retro-spective, case series	27	55.1 (12.8)	81.5	NR	NR	NR	Implantation between October 2003 and April 2006	NR

Struber et al, 2008 [16]	Hanover, Germany	HeartMate II	Retrospective, case series	101	48 (13)	NR	NR	BTT (69.3) DT (30.7)	NR	12 European centers between March 2004 and January 2007	NR
Morshuis et al, 2009 [47]	Multicenter	DuraHeart	Prospective, observational	33	55.5 (12.5)	85.0	NR	BTT (100.0)	242 (243) d	Surgical contraindication to LVAD, high-risk cardiothoracic surgery within 30 days, aortic regurgitation, severe COPD, >1 week of ventilator support, active infection, end-stage renal or	NR

										liver disease, primary RV dysfunction	
Lahpor et al, 2010 [48]	Multi-center	HeartMate II	Registry review	411	51.0 (14.0)	81.0	NR	NR	236 (214) d	HeartMate II implanted in 1 of 64 European centers that contribute to the Thoratec data bank	Implantation <6 mo before study inception
Topkara et al, 2010 [32]	Missouri, USA	HeartMate II, Ventr-Assist	Retro-spective, case series	81	51.8 (13.7)	78.0	White (77) African American (23)	DT (29.6) BTT (70.4) ICM (46.7)	9.2 (9.2) mo	NR	NR
Wieselthaler et al, 2010 [49]	Multi-center	Heart-Ware HVAD	Nonran-domized control-led trial	23	48 (12.6)	87.0	NR	ICM (30.0)	167 (143) d	Refractory end-stage heart failure with optimal medical	Mechanical circulatory support (except IABP); cardiac transplant within 12

											therapy and inotropes. UNOS status 1A or 1B	mo; mortality within 14 days; >72 h mechanical ventilation; PE within 2 weeks; mechanical valve; aortic regurgitation; active, uncontrolled infection; thrombocytopenia; uncontrolled coagulopathy; dialysis; liver failure
Bogaev et al, 2011 [39]	Multi-center	HeartMate II	Secondary analysis of data from Heart-Mate II	465	51.8 (13.2)	77.6	NR		BTT (100.0) ICM (44.9)	338.9 (335.9) d	At least 18 mo follow-up	HeartMate II clinical trial

			clinical trial and continuous access protocol								
Garbade et al, 2011 [50]	Leipzig, Germany	HeartMate II or HeartWare	Retrospective, cohort	49	53 (12)	90.0	NR	DT (16.0) BTT (84.0)	138 (53) d	Implantation between 2006 and 2010	NR
John et al, 2011 [25]	Minnesota, USA	HeartMate II	Retrospective, cohort	102	52.6 (12.8)	74.5	NR	BTT (100.0)	327 (286) d	BTT	Exchange for device failure or destination therapy
John et al, 2011 [51]	Multicenter	HeartMate II	Registry study	1982	NR	77.2	NR	BTT (100.0)	9.7 mo	CF LVAD as BTT, data as reported to INTERMACS and from the	NR

										original HeartMate II clinical trial	
Schaffer et al, 2011 [15]	Mary-land, USA	HeartMate II	Retro-spective, case series	86	49.7, mean	70.9	NR	DT (33.7) BTT (66.3)	NR	Implantation between June 2000 and May 2009	NR
Starling et al, 2011 [25]	Multi-center	HeartMate II	Registry review	169	NR	78.0	White (74) African American (17)	BTT (100.0)	306 (173) d	INTERMACS registry for BTT between April and August 2008	NR
Aggarwal et al, 2012 [20]	Illinois, USA	HeartMate II	Retro-spective, cohort	87	62 (12.8)	86.0	White (36) African American (49)	NR ICM (57.4)	923.5 (567.3) d	Consecutive patients, between 2005 and 2009	Episode of transient bacteremia
Brewer et al, 2012 [52]	Multi-center	HeartMate II	Retro-spective,	896	56.8 (14.1)	76.1	White (71.9) African	NR	NR	Enrollment in HeartMate II	Exchange from HeartMate XVE to

			Heart-Mate II BTT and DT trials				American (20.2)			clinical trials for BTT or DT	HeartMate II
Bomholt et al, 2011 [53]	Copen-hagen, Den-mark	HeartMate II	Retro-spective, cohort	31	46 (24-55)	74.0	White (100.0)	BTT (81.0) DT (19.0) ICM (26.0)	317 (93-595) d	Consecutive patients	NR
Chamo-georgakis et al, 2012 [27]	Ohio, USA	HeartMate II	Retro-spective, case series	135	54 (14)	78.5	NR	BTT (40.0) BTD (39.0) DT (21.0)	NR	NR	NR
Donahey et al, 2012 [31]	Georgia, USA	NR	Retro-spective, case series	57	NR	NR	NR	NR	NR	NR	NR
Eleuteri et al, 2012 [54]	Pennsyl-vania,	HeartMate II, Heart-	Retro-spective,	97	59 (10)	81.0	NR	BTT (33.0) BTC (21.6)	3359 (340) d	Implantation between 2006	NR

	USA	Ware HVAD	cohort					DT (47.4)		and 2011	
Fleissner et al, 2012 [29]	Hanover, Ger-many	Heart-Ware HVAD	Retro-spective, cohort	81	52 (16.1)	82.7	White (100.0)	ICM (45) NICM (55)	258 (531) d	Implantation in 2008, 2009, or 2011	NR
Goldstein et al, 2012 [30]	Multi-center	NR	INTERM ACS registry study	2006	NR, although younger age was a risk factor for percutan-eous infection	NR, al-though older men were at in-creased risk for infec-tion	NR	NR	NR	Implantation between 6/2006 and 9/2010	NR
Guerrero-Miranda et al, 2012 [55]	New Jersey, USA	HeartMate II, DeBakey	Retro-spective, cohort	120	NR	NR	NR	NR	NR	NR	NR

		Micro-Med, Centri-Mag, Dur-aHeart, Ventr-Assist, Heart-Ware									
Hozayen et al, 2012 [56]	Minne-sota, USA	Heart-Ware, Ventr-Assist, Heart-Mate II	Retro-spective, cohort	63	57.5 (17.4)	68.2	NR	ICM (52.4) NICM (47.6)	NR	NR	NR
Kamdar et al, 2015 [57]	Multi-center	NR	Registry study	2900	NR	NR	NR	NR	NR	All patients entered in	NR

										INTERMACS registry between 6/2006 and 3/2011	
Krabatsch et al, 2012 [58]	Berlin, Germany	HeartWare HVAD	Retrospective, case series	142	55.1 (15.9)	82.3	NR	NR	206 d, mean follow- up	Between 9/2009 and 10/2011	Children, patients with congenital heart disease
Maiani et al, 2012 [59]	Multisite, Italy	Jarvik 2000	Registry study	65	63.0 (8.0)	89.2	NR	DT (95) ICM (53)	320 d, mean	Between 2006 and 2011	NR
Mano et al, 2012 [60]	Pittsburgh, USA	CF LVAD	Retrospective, cohort	78	NR	NR	NR	NR	260 (265) d	Between 12/2006 and 6/2011	NR
Menon et al, 2012 [61]	Aachen, Germany	HeartMate II	Retrospective, cohort	40	58.0 (11.0)	NR	NR	DT (22.5) BTT (62.5) BTC (15.0) ICM (72.5)	NR	NYHA IIIB or IV heart failure, between 2008 and 2011	NR
Park et al,	Multi-	HeartMate	Registry	281	63.3	76.0	NR	DT (100.0)	1.7 y, mean	≥2 y follow-up	Prior HeartMate XVE

2012 [62]	center trial	II	study		(12.6)			ICM (24.0)			
Popov et al, 2012 [63]	Hare-field, United King-dom	Heart-Ware HVAD	Retro-spective, case series	34	51.0 (10.0)	85.3	NR	NR	261 (264) d	Implantation between 2007 and 2011	NR
Schibilsky et al, 2012 [64]	Tubin-gen, Ger-many	HeartMate II or Ventr-Assist	Retro-spective, case series	43	55.7 (13.3)	83.7	NR	DT (25.6) BTT (74.4)	NR	Implantation between 2006 and 2010	NR
Tarzia et al, 2012[65]	Mult-icenter, Italy	Jarvik 2000	Registry review	65	65, median	89.2	NR	ICM (53.0)	NR	Implantation between 2006 and 2011	NR
Aldeiri et al, 2013 [21]	Texas, USA	HeartMate II	Retro-spective, cohort	149	55.5 (13)	75.8	NR	ICM (59.0)	NR	Implantation between 2008 and 2012	NR
Choudhary et	New	HeartMate	Prospec-	171	54.0	82.0	NR	NR	NR	Implantation	Death within 3 mo of

al, 2013 [28]	York, USA	II	tive, observa-tional cohort		(12.4)					between 11/2006 and 1/2013	device explant
Forest et al, 2013 [23]	New York, USA	NR	Retro-spective, cohort	105	56 (14)	82.0	NR	DT (45.0) ICM (51.0)	NR	Implantation between 2006 and 2012	NR
Haj-Yahia et al, 2007 [66]	Minne-sota, USA	HeartMate II	Registry study	115	62 [53-69]	83.0	NR	DT (64.0) BTT (36.0)	NR	Survival to discharge, between 2008 and 2011	NR
Lalonde et al, 2013 [67]	Toronto, Canada	HeartMate II and Heart-Ware HVAD	Retro-spective, case series	46	50.1 (12.6)	60.8	NR	BTT (76.2) BTC (19.5) DT (4.3) ICM (26.1)	NR	Implantation between 1/2006 and 4/2012	NR
Nienaber et al, 2013 [36]	Minne-sota,	HeartMate II,	Retro-spective,	78	56.8 (14.9)	79.0	White (87.0) African	DT (62.0) BTT (38.0)	1.5 (1.0) y	Implantation between 2005	LVAD implanted elsewhere, RVAD

	USA	Jarvik 2000, Ventr-Assist	case series				American (7.0)			and 2011	
Slaughter et al, 2013 [68]	Ken-tucky, USA	Heart-Ware HVAD	Pro-spective, observa-tional	332	52.8 (11.9)	71.1	White (68.7) African American (25.9)	BTT (100.0) ICM (36.7)	NR	UNOS status 1A or 1B	Other mechanical circulatory device (except IABP)
Smedira et al, 2013 [17]	Ohio, USA	HeartMate II	Retro-spective, case series	92	53 (14)	78.0	NR	DT (22.0) BTT (78.0)	NR	Implantation between 10/2004 and 1/2010	NR
Stulak et al, 2013 [69]	Minne-sota, USA	HeartMate II	Retro-spective, case series	285	54, mean	51.0	NR	DT (41.0) BTT (39.0) ICM (53.0)	NR	Primary VAD implantation	NR
Tong et al, 2013 [26]	Ohio, USA	HeartMate II	Retro-spective,	254	NR	NR	NR	NR	NR	Between 2004 and 2012	NR

			case series								
Wu et al, 2013 [70]	Berlin, Germany	HeartWare HVAD	Retrospective, case review	141	51.6 (16.2)	82.5	NR	DT (28.4) BTT (71.6) ICM (44.7)	NR	Between 8/2009 and 4/2011	NR
Baronetto et al, 2014 [40]	Turin, Italy	HeartWare HVAD	Prospective, observational cohort	23	57.5	100.0	White (100.0)	BTT (52.0) DT (48.0)	7 mo	Implant with HeartWare HVAD between 4/2013 and 11/2013	NR
Cagliostro et al, 2014 [41]	New York, USA	HeartMate II (other devices unspecified)	Prospective, observational cohort	253	NR	NR	NR	NR	NR	Implantation between 2010 and 2013	NR
Chan et al, 2014 [71]	Singapore,	HeartMate II or	Retrospective,	40	41.0	NR	NR	NR	NR	Implantation between 5/2009	NR

	Singa-pore	Heart-Ware HVAD	cohort							and 9/2013	
Cogswell et al, 2014 [72]	Minne-sota, USA	HeartMate II or Heart-Ware HVAD	Matched cohort	60	43 (14.6)	80.0	White (73.3) African American (16.6) Asian (1.6)	BTT (95.0) DT (5.0) ICM (30.0)	NR	Age >16 y; DSM, IV substance abuse (case arm) or documented lack thereof (matched cohort)	Death in hospital, contraindications to transplantation
Dean et al, 2014 [73]	Multi-center	HeartMate II	Secondary analysis of Heart-Mate II destina-tion therapy	401	60, median	NR	NR	BTT (50.0) DT (50.0)	19 (7-46) mo	Inclusion in HeartMate II registry database	NR

			clinical trial								
Hieda et al, 2014 [74]	Osaka, Japan	NR	Retro-spective, case series	16	37.5 (11.9)	100.0	Asian (100.0)	BTT (100.0) ICM (18.8)	387 (228) d	BTT, between 2011 and 2013	NR
Jennings et al, 2014 [75]	Detroit, USA	NR	Retro-spective, case series	16	52, median	69.0	NR	DT (69.0) BTT (31.0)	NR	Between 1/2008 and 8/2011, with systemic antimicrobial agent therapy for suppression of confirmed LVAD infection	Superficial percutaneous driveline infection
John et al, 2014 [76]	Multi-center	Heart-Ware HVAD	Registry study	332	52.7 (11.9)	71.1	NR	BTT (100.0) ICM (36.7)	NR	Secondary analysis of ADVANCE BTT and CAP	NR

										trial with ≥6 mo follow-up	
Jorde et al, 2014 [77]	Multi-center	HeartMate II	Registry study	380	NR	81.8	White (74.5) African American (18.7)	BTT (65.0) DT (35.0) ICM (60.0)	NR	First 247 patients who had a HeartMate II implant after FDA device approval and 133 patients in the original HeartMate II clinical trial	NR
Kimura et al, 2014[33]	Tokyo, Japan	DuraHeart Evaheart	Retrospective, case series	31	39.7 (11.7)	84.0	NR	BTT (100.0) ICM (12.9)	NR	End-stage heart failure, BTT	HeartMate II device implantation
Koval et al, 2014 [78]	Ohio, USA	HeartMate II	Retro-spective, case	181	54 (13.8)	80.0	White (79.0) Other races unspecified	DT (29) BTT (71) ICM (46)	NR	Implantation between 10/2004 and	Previous LVAD

			series							9/2011	
Kretlow et al, 2014 [14]	Texas, USA	CF LVAD	Retro-spective, case series	26	51.3 (15.7)	81.0	NR	DT (7.7) BTT (92.3)	NR	All patients treated by the senior author for LVAD infection	NR
Masood et al, 2014 [37]	Michi-gan, USA	CF LVAD	Retro-spective, case series	328	56, median	77.0	NR	NR	NR	NR	NR
Moazami et al, 2014 [79]	Multi-center	DuraHeart	Prospec-tive, observa-tional study	63	54 (11.3)	84.0	NR	BTT (100.0) ICM (49.0)	NR	Advanced heart failure in patients listed for transplant at 1 of 40 investigator centers	NR
Nelson et al,	Pennsyl-	HeartMate	Retro-	12	54.3	75.0	White (86.0)	DT (42.0)	NR	Patients who	NR

2014 [80]	vania, USA	II and HeartWare HVAD	spective, case series		(19.3)		African American (14.0)	BTT (58.0) ICM (58.0) DCM (17.0) NICM (17.0) Familial (8.0)		required plastic surgery for complex wound management, between 2008 and 2013	
Nishi et al, 2014 [81]	Osaka, Japan	HeartWare HVAD	Prospective, cohort	9	33.5 (7.8)	66.7	NR	BTT (100.0) ICM (0)	245 (162) d	Patients eligible for cardiac transplantation, taking maximal medical therapy	NR
Raymer et al, 2014 [82]	Missouri, USA	HeartMate II HeartWare HVAD (35)	Retrospective case series	316	NR	78.0	NR	NR	NR	Implantation between 6/2005 and 7/2013	NR
Sabashnikov et al, 2014 [8]	Harefield,	HeartMate II or	Retrospective,	139	44 (13.7)	NR	NR	BTT (100.0) ICM (11.0)	514 (481) d	Implantation between 2007	NR

	United King-dom	Heart-Ware HVAD	cohort					DCM (83.0) PPM (1.0) HCM (5.0)		and 2013	
Singh et al, 2014 [83]	Wiscon-sin, USA	HeartMate II	Retro-spective, case series	125	NR	NR	NR	NR	628 (231.1) d	Implantation between 6/2008, and 10/2011	NR
Subbotina et al, 2014 [84]	Ham-burg, Ger-many	Heart-Ware HVAD	Retro-spective, case series	38	57 (12)	NR	NR	ICM 31.6	10 (7) mo	Implantation between 1/2010 and 8/2013	NR
Takeda et al, 2014 [85]	New York, USA	HeartMate II, Ventr-Assist, Dura-Heart, DeBakey Micro-	Retro-spective, case series	140	54.7 (14.4)	79.3	ICM (36.4)	DT (17.9) BTT (82.1)	NR	Implantation between 2004 and 2010	NR

		Med									
Abou el ela et al, 2015 [86]	Missouri, USA	HeartMate II and Heart-Ware HVAD	Retro-spective, case series	363	NR	NR	NR	NR	NR	Implantation between 2009 and 2013	NR
Akhter et al, 2015 [34]	Wiscon-sin, USA	HeartMate II (120) Heart-Ware HVAD (1) DeBakey Micro-Med (1)	Retro-spective, case series	122	53 (12.9)	77.0	NR	ICM (43.6)	370 (336) d	Implantation between 2007 and 2013	NR
Birks et al, 2015 [87]	Multi-center	Heart-Ware HVAD	Registry study	332	52.7 (11.9)	71.1	White (68.7) African American	BTT (100) ICM (36.7)	NR	Secondary analysis of ADVANCE	NR

							(26.7)			BTT and CAP trial, ≥6 mo follow-up	
Fried et al, 2015 [11]	New York, USA	HeartMate II, Heart-Ware HVAD	Retro-spective, case series	298	NR	NR	NR	NR	NR	Implantation between 2008 and 2014	NR
Fudim et al, 2015 [88]	Tenn-essee, USA	Heart-Ware HVAD, Heart-Mate II	Retro-spective, case series	161	NR	NR	NR	NR	NR	Implantation between 2009 and 2014	NR
Haeck et al, 2015 [89]	Leiden, Nether-lands	Heart-Ware HVAD	Retro-spective, case series	16	61 (8)	81.0	NR	DT (100.0) ICM (81.0)	NR	Consecutive LVAD implants	NR
Haglund et al, 2015 [45]	Tenn-essee,	HeartMate II, Heart-	Registry study	81	52.6 (10.6)	78.0	NR	BTT (100.0)	NR	Patients in the Vanderbilt	DT, died before the index hospitalization,

	USA	Ware HVAD								Advanced Heart Failure Registry	implantation with temporary or pulsatile LVAD, RVAD, or TAH
Harvey et al, 2015 [90]	Minne-sota, USA	HeartMate II	Retro-spective, cohort	230	57.0 (14.0)	80.4	NR	BTT (80.4) DT (19.6)	NR	Implantation between 2006 and 2013	NR
Henderson et al, 2015 [91]	Illinois, USA	CF LVAD	Retrospec -tive, cohort	56	52.4 (12.5)	NR	NR	NR	NR	Implantation between 2008 and 2014	NR
Imamura et al, 2015 [13]	Japan	Evaheart, Dura-Heart, Heart-Mate II, Jarvik 2000, Heart-	Retro-spective, cohort	57	40.0 (12.0)	79.0	Asian (100.0)	BTB (9.0) ICM (5.0)	421 (325) d	NR	Driveline infection before first discharge

		Ware HVAD									
Krishna-moorthy et al, 2014 [92]	North Caro-lina, USA	HeartMate II	Retro-spective, case series	5	63.0 (12.2)	100.0	NR	DT (100.0) ICM (80.0)	NR	CIED lead removal after LVAD implant and ISHLT-defined LVAD infection	NR
Lushaj et al, 2015 [93]	Wiscon-sin, USA	HeartMate II, Heart-Ware HVAD	Retro-spective, case series	128	57.8	84.3	NR	DT (32.6) BTT (67.4) ICM (22.6)	NR	Between 1/2008 and 6/2014	NR
Majure et al, 2015 [9]	District of Colum-bia, USA	HeartMate II, Heart-Ware HVAD	Retro-spective, case series	141	54.6 (13.6)	74.0	African American (61.7) Other races not specified	DT (36.1) BTT (63.9) ICM (35.0)	NR	Implantation between 2011 and 2014	Death before discharge

Maltais et al, 2015 [94]	Multi-center	Heart-Ware HVAD	Registry study	382	NR	NR	NR	NR	NR	Secondary analysis of ADVANCE BTT and CAP trial	NR
Matsumoto et al, 2015 [10]	Osaka, Japan	Evaheart, Heart-Mate II	Retro-spective, cohort	39	NR	NR	NR	NR	NR	Implantation between 2007 and 2014	NR
McCandless et al, 2015 [95]	Utah, USA	HeartMate II	Retro-spective, cohort	57	56 (14.6)	87.7	NR	DT (25.0) BTT (75.0)	302 (302) d	Utah Artificial Heart Program Database, between 2008 and 2012	NR
McMenamy et al, 2015 [96]	Sydney, Aus-tralia	CF LVAD	Retro-spective, cohort	85	NR	NR	NR	NR	NR	Implantation between 2010 and 2014	NR
Nishinaka et al, 2015 [18]	Japan	Evaheart	Registry review	108	42.0 (19)	NR	NR	NR	NR	Advanced heart failure, J-	NR

										MACS registry	
Ono et al, 2015 [97]	Japan	HeartMate II	Registry review	104	41.7	76.0	NR	BTT (100)	299.2 d	J-MACS registry between 2013 and 2014	NR
Potapov et al, 2015 [98]	Europe	HeartMate II	Retro-spective, cohort	479	NR	NR	NR	ICM (46.6) DCM (49.5)	610 (592) d	Implant done at 1 of 3 high-volume European centers between 2006 and 2014	NR
Trachtenberg et al, 2014 [22]	Texas, USA	HeartMate II	Retro-spective, case series	149	55.4 (13)	76.0	NR	ICM (59.1)	642 (531) d	Implantation between 2008 and 2012	NR
Tsiouris et al, 2015 [99]	Connecti cut, USA	HeartMate II (136) Heart-Ware	Retro-spective, cohort	149	53.7 (12.1)	74.0	White (59.0) African American (41.0)	BTT (54.3) DT (45.7) ICM (37.0) NICM (63.0)	435.7 (392.2) d	Implantation between 2006 and 2013	NR

		HVAD (13)									
Van Meeteren et al, 2015 [12]	USA	NR	Registry review	734	57, median	78.6	NR	NR	NR	Hospital in Mechanical Circulatory Support Registry Network, between 2004 and 2014	NR
Wus et al, 2015 [100]	Pennsyl-vania, USA	HeartMate II	Retro-spective, case series	68	57 (11.4)	80.9	White (60.3) Other races not specified	NR	NR	First implant	No ICU-intermediate care–discharge pathway, implant at outside hospital, OHT during index hospitalization, never left ICU, had pump exchange

Yoshioka et al, 2014 [101]	Osaka, Japan	Jarvik 2000	Retro-spective, case series	9	57 (11.0)	77.8	NR	DT (22.8) BTT (77.2)	725 d, median	NR	NR
Yost et al, 2015 [19]	Illinois, USA	NR	Retro-spective, case series	134	58 (13.1)	73.1	NR	NR	NR	Implantation between 2012 and 2014	NR

Abbreviations: ADVANCE, Ventricular Assist Device for the Treatment of Advanced Heart Failure; BTB, bridge to bridge; BTC, bridge to candidacy; BTD, bridge to destination therapy; BTT, bridge to transplant; CAP, continuous-access protocol; CF, continuous flow; CIED, cardiovascular implantable electronic device; COPD, chronic obstructive pulmonary disease; DCM, dilated cardiomyopathy; DSM, *Diagnostic and Statistical Manual of Mental Disorders*; DT, destination therapy; HCM, hypertrophic cardiomyopathy; IABP, intraaortic balloon pump; ICM, ischemic cardiomyopathy; ICU, intensive care unit; INTERMACS, Interagency Registry for Mechanically Assisted Circulatory Support; ISHLT, International Society for Heart and Lung Transplant; IV, intravenous; J-MACS, Japanese Registry for Mechanically Assisted Circulatory Support; LVAD, left ventricular assist device; NICM, nonischemic cardiomyopathy; NR, not recorded; OHT, orthotopic heart transplant; PE, pulmonary embolus; PPM, peripartum cardiomyopathy; RV, right ventricular; RVAD, right ventricular assist device; TAH, total artificial heart.

[a] Data presented as mean (standard deviation) or median (interquartile range)

Table 2. Patients' Comorbidities[a]

		Cardiac Resynchronization		
Study	**BMI (kg/m^2)**	**INTERMACS Score**	**Device, %**	**Diabetes Mellitus, %**
Miller et al, 2007[46]	26.8 (5.9)	NR	NR	NR
Schulman et al, 2007 [24]	NR	NR	NR	37.0
Struber et al, 2008 [16]	NR	NR	NR	NR
Morshuis et al, 2009 [47]	NR	NR	CRT, 82	NR
Lahpor et al, 2010 [48]	NR	NR	NR	NR
Topkara et al, 2010 [32]	28.0 (5.6)	NR	NR	33.3
Wieselthaler et al, 2010 [49]	27.6, mean	NR	69.6	NR
Bogaev et al, 2011 [39]	NR	NR	CRT, 49.4	NR
			ICD, 76.3	
Garbade et al, 2011 [50]	NR	1.7 (0.74)	NR	NR
John et al, 2011 [25]	28.7 (6.8)	3.6 (1.7)	NR	28.4
John et al, 2011 [51]	28.4 (9.1)	2.5 (2.9)	NR	NR
Schaffer et al, 2011 [15]	28.3 (7.0)	2.6 (1.0)	80.2	NR
Starling et al, 2011 [25]	NR	NR	NR	NR
Aggarwal et al, 2012 [20]	27.26 (6.4)	NR	NR	NR

Brewer et al, 2012 [52]	26.5 (5.9)	NR	53.1	NR
Bomholt et al, 2011 [53]	24.2 (21.1-27.3)	NR	CRT, 83.9 (ICD, 25/31; CRT-P, 1)	16.1
Chamo-georgakis et al, 2012 [27]	NR	NR	NR	NR
Donahey et al, 2012 [31]	NR	NR	NR	NR
Eleuteri et al, 2012 [54]	NR	NR	NR	NR
Fleissner et al, 2012 [29]	26.9 (4.6)	NR	ICD, 100.0	14.8
Goldstein et al, 2012 [30]	NR	NR, although noted not to be a significant predictor of infection risk	NR	NR, although noted not to be a significant predictor of infection risk
Guerrero-Miranda et al, 2012 [55]	NR	NR	NR	NR
Hozayen et al, 2012 [56]	29.5 (6.1)	NR	NR	39.7
Kamdar et al, 2015 [57]	NR	NR	NR	NR
Krabatsch et al, 2012 [58]	NR	NR	NR	NR
Maiani et al, 2012 [59]	NR	NR	NR	NR

Mano et al, 2012 [60]	NR	NR	NR	NR
Menon et al, 2012 [61]	NR	NR	NR	NR
Park et al, 2012 [62]	NR	NR	NR	NR
Popov et al, 2012 [63]	26.0 (6.0)	NR	NR	21.0
Schibilsky et al, 2012 [64]	NR	NR	NR	NR
Tarzia et al, 2012[65]	NR	3.1	NR	NR
Aldeiri et al, 2013 [21]	28.5 (7.0)	NR	NR	46.3
Choudhary et al, 2013 [28]	NR	NR	NR	NR
Forest et al, 2013 [23]	NR	NR	NR	NR
Haj-Yahia et al, 2007 [66]	NR	NR	NR	34.0
Lalonde et al, 2013 [67]	24.1 (5.1)	3.2 (0.7)	NR	23.9
Nienaber et al, 2013 [36]	29.4 (6.1)	NR	87.0	39.0
Slaughter et al, 2013 [68]	28.2 (6.1)	3 (2-3)	NR	NR
Smedira et al, 2013 [17]	27 (6.0)	NR	NR	38.0
Stulak et al, 2013 [69]	NR	NR	NR	21.0
Tong et al, 2013 [26]	NR	NR	NR	NR
Wu et al, 2013 [70]	25.8 (5.1)	2 (1-3)	54.6	28.4
Baronetto et al, 2014 [40]	24.4	Median 3 (range, 2-4)	78.2	13.0

Cagliostro et al, 2014 [41]	NR	NR	NR	NR
Chan et al, 2014 [71]	>25, 81% overweight	NR	NR	NR
Cogswell et al, 2014 [72]	30 (7.5)	3.6 (1.9)	NR	15.0
Dean et al, 2014 [73]	NR	NR	NR	NR
Hieda et al, 2014 [74]	NR	NR	0	NR
Jennings et al, 2014 [75]	NR	NR	NR	NR
John et al, 2014 [76]	28.2 (6.1)	NR	NR	NR
Jorde et al, 2014 [77]	NR	NR	NR	44.2
Kimura et al, 2014[33]	NR	2.2 (0.8)	NR	NR
Koval et al, 2014 [78]	28 (5.9)	2.5 (3.3)	NR	NR
Kretlow et al, 2014 [14]	NR	NR	NR	NR
Masood et al, 2014 [37]	NR	NR	NR	NR
Moazami et al, 2014 [79]	NR	NR	NR	NR
Nelson et al, 2014 [80]	29.3 (8.0)	NR	NR	58.3
Nishi et al, 2014 [81]	NR	2.3 (0.5)	NR	NR
Raymer et al, 2014 [82]	NR	NR	NR	NR
Sabashnikov et al, 2014 [8]	26.0 (5.0)	2.4 (1.1)	46.0	13.0

Singh et al, 2014 [83]	NR	NR	NR	NR
Subbotina et al, 2014 [84]	NR	NR	NR	NR
Takeda et al, 2014 [85]	NR	NR	82.9	31.4
Abou el ela et al, 2015 [86]	NR	NR	NR	NR
Akhter et al, 2015 [34]	NR	3.0, median	NR	26.7
Birks et al, 2015 [87]	28.2 (6.1)	NR	NR	NR
Fried et al, 2015 [11]	NR	NR	NR	NR
Fudim et al, 2015 [88]	NR	NR	NR	NR
Haeck et al, 2015 [89]	NR	3.4 (1.3)	75.0	25.0
Haglund et al, 2015 [45]	28.8 (5.5)	2.9 (1.0)	NR	41
Harvey et al, 2015 [90]	NR	NR	NR	34.2
Henderson et al, 2015 [91]	NR	NR	NR	NR
Imamura et al, 2015 [13]	20.5 (2.9)	2.5 (0.6)	42.0	3.5
Krishna-moorthy et al, 2014 [92]	31 (6.3)	NR	100.0	60.0
Lushaj et al, 2015 [93]	28.2 (5.6)	2.7	81.3	40.6
Majure et al, 2015 [9]	28.3 (5.9)	NR	NR	37.5
Maltais et al, 2015 [94]	NR	NR	NR	NR

Matsumoto et al, 2015 [10]	NR	NR	NR	NR
McCandless et al, 2015 [95]	26.8 (5.0)	NR	NR	NR
McMenamy et al, 2015 [96]	NR	NR	NR	NR
Nishinaka et al, 2015 [18]	NR	NR	NR	NR
Ono et al, 2015 [97]	NR	NR	NR	NR
Potapov et al, 2015 [98]	NR	2 (1-3)	NR	NR
Trachtenberg et al, 2014 [22]	28.4 (7.1)	NR	NR	46.3
Tsiouris et al, 2015 [99]	28.4 (5.6)	2.8 (1.1)	25.3	45.0
Van Meeteren et al, 2015 [12]	NR	NR	NR	NR
Wus et al, 2015 [100]	28.6 (5.9)	NR	NR	39.0
Yoshioka et al, 2014 [101]	NR	1.8 (0.35)	NR	NR
Yost et al, 2015 [19]	NR	NR	NR	NR

Abbreviations: BMI, body mass index; CRT, cardiac resynchronization therapy; CRT-P, cardiac resynchronization therapy, with pacemaker; ICD, implantable cardioverter-defibrillator; INTERMACS, Interagency Registry for Mechanically Assisted Circulatory Support; NR, not reported.

[a] Data presented as mean (standard deviation) or median (IQR).

Table 3. Infection and Outcome Data

Study	Incidence of Infection	Type of Infection	Outcome of Infection	Outcome of Treatment	Microorganisms	Comments/Limitations
Miller et al, 2007[46]	19 LVAD infections	DLI, 100.0%	NR	NR	NR	Pacemaker lead-related infections occurred later in the course of treatment
Schulman et al, 2007 [24]	11 LVAD infections	DLI, 18.8% BSI, 63.6% Endocardial infection, 9.1%	NR	NR	NR	NR
Struber et al, 2008 [16]	24 LVAD infections	0.37 DLI/patient y	Of 21 DLI, 6 recurred; no mortality associated with DLI	NR	NR	NR
Morshuis et al, 2009 [47]	24 infections 18 LVAD infections	DLI, 72% PPI, 28%	NR	NR	NR	NR
Lahpor et al, 2010	NR	0.19-0.61 DLI/patient	0.13-0.62 deaths	NR	NR	Combined results of 3 studies

[48]		y 0.07-0.09 PPI/patient y	attributable to infection			
Topkara et al, 2010 [32]	42 patients with at least 1 episode of infection (number of infections not specified)	PPI, 78.0% DLI, 22.0% 8.6% developed *Clostridium difficile* infection	Sepsis (18.5%) associated with decreased survival Overall mortality from LVAD infections, 19.7%	1 patient required LVAD explantation	DLI: MRSA (27.2%) *Pseudomonas aeruginosa* (18.1%) MSSA (9%) *Serratia marcescens* (9%) *Citrobacter koseri* (9%) *Enterobacter cloacae* (9%) *Stenotrophomonas maltophilia* (9%) *Klebsiella pneumonia* (9%) PPI: MRSA, 1 (16.6%) CoNS, 2 (33.3% *P aeruginosa*, 1 (16.6%) *C koseri*, 1 (16.6%)	Infection was associated with greater length of hospital stay and mortality

					N sicca, 1 (16.6%)	
Wieselthaler et al, 2010 [49]	16 infections 8 LVAD infections	DLI, 100%	NR	7 treated with antimicrobial agents alone; 1 treatment failed and debridement required	NR	NR
Bogaev et al, 2011 [39]	89 patients with at least one infection (number of infections not specified)	20 LVAD infections; subtypes not specified	NR	NR	NR	Excluded transient bacteremia
Garbade et al, 2011 [50]	6 LVAD infections	Only DLI reported	NR	NR	NR	NR
John et al, 2011 [25]	22 LVAD infections	DLI, 100.0%	NR	NR	NR	Before FDA device approval, the rate of driveline infection was 26.3%, which decreased to 18.8% after FDA approval
John et al, 2011 [51]	1,113 infections in 556 patients	303 LVAD infections: PPI, 33	NR	NR	NR	NR

		BSI, 233 Endocardial, 5 Line sepsis, 41 Other, 386				
Schaffer et al, 2011 [15]	140 infections 68 LVAD infections	DLI, 30.0% PPI, 28.0% Sternal wound, 2%	NR	NR	NR	NR
Starling et al, 2011 [25]	142 infections	DLI, 31.7% PPI, 2.8% BSI, 33.1% Line sepsis, 1.4% Other, 60.5%	NR	NR	NR	NR
Aggarwal et al, 2012 [20]	30 infections	BSI only	BSI was associated with increased risk of hemorrhagic and ischemic stroke	NR	CoNS, 47.1% *Candida* spp, 8.8% *Enterococcus faecalis*, 8.8% *Achromobacter xylosoxidans*, 5.9%	The study aim was to show sex differences in LVAD complications; higher strokes and fewer infections were reported for women

					MRSA, 5.9% MSSA, 5.9% *Bacillus* spp, 2.9% *Corynebacterium* spp, 2.9% *E cloacae*, 2.9% *P aeruginosa*, 2.9% *Streptococcus mitis*, 2.9% Other *Streptococcus* spp, 2.9%	
Brewer et al, 2012 [52]	230 LVAD infections	NR	NR	NR	NR	Sepsis and device-related infections increased as BMI increased to >35
Bomholt et al, 2011 [53]	55 infections in 12 patients	DLI, 55 No BSI, PPI, or others reported	All patients treated with antibiotics alone; no LVAD explantations	Patients had 1-8 relapses, but none required device explantation	*Staphylococcus aureus* (33%) *Corynebacterium* spp (15%) *E faecalis* (13%) *E coli* (14%)	Infection rates were low, and those that occurred were easily managed

					Klebsiella spp (7%) *E cloacae* (3%) *Proteus* spp (3%)	
Chamogeorgakis et al, 2012 [27]	34 infections	DLI, 26 (67.0%) PPI, 8 (21.0%)	2 deaths, both in patients with infections managed with medical therapy	5 patients had device exchange; 2, device removal; 1, recurrence; 6 infections required surgical débridement	*S aureus* (33%) CoNS (7%) *Pseudomonas* spp (27%) *Klebsiella* spp (7%) *Serratia* spp (7%) *Proteus* spp (7%) *Candida* spp (7%)	Major risk factor for recurrence was continued device need; recommended a workup to determine if device reimplantation was necessary after explantation in all cases
Donahey et al, 2012 [31]	17 MDRO LVAD infections	NR	Infections were associated with longer length of stay but not mortality	NR	MRSA was the most common MDRO	Risk factors for MDRO included exposed driveline, hospital length of stay, and age
Eleuteri et al, 2012 [54]	23 infections	DLI, 100%	NR	NR	NR	Study included implementation of a driveline grading system–based approach to site care,

						with a significant drop in driveline infection rate (36.3% to 16.0%)
Fleissner et al, 2012 [29]	20 infections	DLI, 100%	No association was observed between LVAD infections and mortality	11 infections were treated medically, with 3 treatment failures requiring device explantation	37 isolates in 20 DLI *S aureus* (6/37) *Staphylococcus epidermidis* (7/37) *Staphylococcus warneri* (1/37) *Staphylococcus lugdunensis* (1/37) *Staphylococcus haemolyticus* (1/37) *S mitis* (1/37) *Staphylococcus dysgalactieae* (1/37) *Proteus mirabilis* (4/37) *Proteus vulgaris* (1/37)	Increased rates of infection associated with obesity, very low ejection fraction, use of fresh frozen plasma during surgery, and not double tunneling the driveline

					Corynebacterium spp (8/37) *Granulicatella* spp (1/37) *Enterococcus* spp (3/37) *Pseudomonas* spp (1/37) *Escherichia* spp (1/37)	
Goldstein et al, 2012 [30]	239 infections in 197 patients	DLI, 100% (percutaneous site)	23 deaths, 6 with sepsis In multivariate analysis, LVAD infection was associated with younger age and did negatively impact survival	20% of infections were associated with sepsis; pneumonia was the most common nondevice-associated infection	NR	Prolonged LVAD use was positively associated with infection, with 19% of patients developing an LVAD infection by 12 mo of support
Guerrero-Miranda et al, 2012 [55]	9 LVAD infections in patients with axial-flow LVADs; 0 in patients	NR	NR	NR	NR	Infections decreased (LVAD and non-LVAD–related) with the later generation of continuous-

	with centrifugal flow devices					flow devices (vs pulsatile and axial devices)
Hozayen et al, 2012 [56]	9 LVAD infections	DLI, 100.0%	NR	NR	NR	Foam dressing was noninferior to gauze for preventing infection and was associated with higher caregiver satisfaction
Kamdar et al, 2015 [57]	294 LVAD infections	DLI, 80.0% PPI, 6.8% BSI, 12.6%	NR	NR	NR	Younger age and prior bypass grafting were risk factors for infection
Krabatsch et al, 2012 [58]	37 LVAD infections	DLI, 75.7% BSI, 24.3%	5.3% of infections progressed to sepsis	NR	NR	NR
Maiani et al, 2012 [59]	3 episodes of sepsis in the first 12 mo after device implantation	NR	NR	NR	NR	INTERMACS score correlated with mortality and infection
Mano et al, 2012 [60]	Rates of infection varied from 19%-25% among groups (stratified by	NR	NR	NR	NR	Lower BMI was associated with more nondevice-related infections

	body surface area)					
Menon et al, 2012 [61]	2 LVAD infections	DLI, 100%	1 death	1 successful débridement, device retained	*S aureus* 2 (100%)	NR
Park et al, 2012 [62]	383 infections 257 LVAD infections	DLI, 27% PPI, 7% BSI, 28% Other LVAD, 30% non-LVAD, 45%	NR	NR	NR	Risk of infection decreased midtrial vs early
Popov et al, 2012 [63]	5 infections	DLI, 100%	NR	NR	NR	NR
Schibilsky et al, 2012 [64]	7 LVAD infections	DLI, 100%	NR	NR	NR	Fewer superficial, late DLI in the double-tunnel group compared with the conventional group
Tarzia et al, 2012[65]	NR	DLI, 5	NR	NR	NR	Postauricular gable and intraventricular pump appeared to be associated with reduced local and systemic infections

						compared with prior studies of LVAD infections
Aldeiri et al, 2013 [21]	33 infections, 19 LVAD-related	NR	*P aeruginosa* BSI associated with stroke	NR	NR	NR
Choudhary et al, 2013 [28]	56 LVAD-related infections	DLI, 91% PPI, 5%	Survival not impacted by infection	NR	15 *Pseudomonas* organisms	*S aureus* infections tended to occur earlier than infections of other organisms, particularly *Pseudomonas* spp
Forest et al, 2013 [23]	27% of patients had at least 1 episode of infection (some recurrent)	DLI, 30% 43% of patients with DLI had bacteremia	Bacteremia did not impact long-term survival, but BSI was associated with longer hospital stay	NR	41% of organisms were *Staphylococcus* spp	NR
Haj-Yahia et al, 2007 [66]	32 infections, 6 LVAD-associated	DLI or PPI, 100%	Infection was a leading cause of readmission	NR	NR	NR

Lalonde et al, 2013 [67]	1.2 (1) infections/patient, including 16 episodes of pneumonia, 10 episodes of urinary tract infection	DLI, 11 episodes BSI, 5 episodes	30-day mortality from LVAD infections, 10.9%	NR	NR	Infection rates were comparable between HeartWare HVAD and HeartMate II
Nienaber et al, 2013 [36]	101 LVAD infections in 78 patients	DLI, 36.6% PPI, 4.0% BSI, 35.6% Cannula infection, 10.9% Mediastinitis, 5.0% CIED, 3.9%	NR	14% of infections required débridement; only 3 required device explant	NR	Candidemia was associated with poor outcome DLI was associated with prolonged therapy and destination therapy. Most superficial infections did not progress to deep infection Outcomes improved with CIED removal for concomitant LVAD/CIED infection
Slaughter et al, 2013 [68]	145 LVAD infections	DLI, 51.7% Sepsis, 48.3%	NR	NR	NR	NR
Smedira et al,	68 infections	DLI, 55.0%	Infection was the	NR	NR	NR

2013 [17]	51 LVAD infections	PPI, 19.6% Septic emboli (device), 7.8% BSI, 5.8%	leading cause of readmission			
Stulak et al, 2013 [69]	NR	DLI, 41 infections 7 infections required device exchange	NR	NR	NR	Study compared prophylactic antibiotics to reduce DLI; no effect noted
Tong et al, 2013 [26]	47 LVAD infections	PPI ± DLI, 23.4% DLI, 76.6%	NR	8 pump exchanges, 11 irrigation and debridement of the driveline or pump	10 patients had isolated bacteremia of no clinical significance; 90% were GPC; 43% of infections were gram positive, 43% gram negative, and 15% anaerobic	Study of late onset infection; late infections occurred in 20% of patients and were associated with worse survival
Wu et al, 2013 [70]	66 infections	DLI, 27.3%	NR	NR	NR	NR
Baronetto et al, 2014 [40]	None	NR	NR	NR	NR	Primary purpose was to evaluate the use of a stat-lock and chlorhexidine disc to prevent

						infection
Cagliostro et al, 2014 [41]	NR	NR	NR	NR	NR	76.3% of patients with a standard dressing did not have a driveline infection vs 88.6% with silver dressing
Chan et al, 2014 [71]	11 infections	DLI, 100%	NR	All patients treated medically, 4 relapses	MSSA (27.6%) CoNS (20.7%)	Pus or discharge was present in 89% of patients
Cogswell et al, 2014 [72]	11 infections	DLI, 100%	Mortality was higher in patients who abused substances	NR	NR	Odds ratio was 5.4 for driveline infection in patients who were substance abusers
Dean et al, 2014 [73]	39 infections	DLI, 100%	NR	NR	NR	Leaving the velour portion of the driveline was associated with fewer infections compared with data from the original HeartMate II DT trial
Hieda et al, 2014 [74]	27 LVAD-associated infections	DLI, 55.6% BSI, 44.4%	No deaths	No medical therapy failed; no transplants	MRSA, 48 (11.9%) MSSA, 39 (9.7%)	Gram-negative bacilli were rarely isolated from the exit site

	required	*Staphylococcus anginosus*, 5 (1.2%) *Staphylococcus capitis*, 10 (2.5%) *Staphylococcus caprae*, 5 (1.2%) *S epidermidis*, 45 (11.1%) *S haemolyticus*, 4 (1.0%) *S lugdunensis*, 26 (6.4%) α-*Streptococcus* spp 9 (2.2%) *Staphylococcus* spp 14 (3.5%) *Corynebacterium* spp 28 (6.9%) *K pneumonia*, 39 (9.7%) *E coli*, 38 (9.4%) *E aerogenes*, 16 (4.0%)

					S maltophilia, 7 (1.7%) *E faecalis*, 22 (5.4%) *M morganii*, 18 (4.5%) *C freundii*, 18 (4.5) *P fluorescens*, 4 (1.0%) *S marcescens*, 9 (2.2%)	
Jennings et al, 2014 [75]	17 infections in 16 patients	DLI, 13 PPI, 1 BSI, 3	NR	Chronic suppression with antibiotics failed in 5 patients; 3 devices had to be explanted	MRSA, 3 (12%) MSSA, 5 (20%) *S marcescens*, 3 (12%) *P mirabilis*, 1 (4%) *P aeruginosa*, 1 (4%) *Staphylococcus maltophilia*, 2 (8%) *Klebsiella* spp, 4 (16%) *Acinetobacter* spp, 1 (4%) *Achromobacter* spp, 2 (8%) *Citrobacter* spp, 1 (4%) *Actinomyces* spp, 1 (4%)	*C difficile* infection, 2 patients

					Corynebacterium spp, 1 (4%)	
John et al, 2014 [76]	113 infections	DLI, 49.6%	NR	NR	*S aureus* was the most common microorganism in DLI	DLI was associated with diabetes mellitus and higher BMI. Sepsis was associated with decreased survival
Jorde et al, 2014 [77]	192 LVAD infections	Before FDA approval, 35%; after approval, 19%	NR	NR	NR	NR
Kimura et al, 2014[33]	17 LVAD infections	DLI, 94.1% BSI, 5.9%	34% of readmissions were attributed to infection; 8 episodes progressed to sepsis	NR	*S aureus* predominated (6 of 8 culture-positive sepsis episodes)	NR
Koval et al, 2014 [78]	89 LVAD infections	DLI, 100% (study was of DLI only)	DLI was associated with a decreased	1/3 of superficial infections progressed	*S aureus* and *Pseudomonas* spp were responsible for	When there was recurrent infection with a new organism,

			rate of survival	despite conservative therapy	1/3 of infections	gram-positive infections occurred after gram-negative infections and vice versa
Kretlow et al, 2014 [14]	26 patients with at least 1 LVAD infection	DLI, 42.3% PPI, 50.0% Endocardium, 8.0%	Successfully treated infections had 29% mortality compared with 67% mortality of treatment failures	1 device was explanted; the patient survived	*P aeruginosa*, 9 (19.6%) *E coli*, 5 (10.9%) VRE, 4 (8.7%) *S marcescens*, 4 (8.7%) *S maltophilia*, 4 (8.7%) CoNS, 3 (6.5%) *E cloacae*, 2 (4.3%) MSSA, 2 (4.3%) MRSA, 1 (1.0%) *Acinetobacter baumannii*, 1 (2.2%) *Actinomyces* spp, 1 (2.2%) *Candida albicans*, 1 (2.2%) *C koseri*, 1 (2.2%) *Eikenella corrodens*, 1	Antibiotic bead and repeat debridement was associated with infection clearance in most patients (65.3%)

					(2.2%) *K pneumonia*, 1 (2.2%) *M morganii*, 1 (2.2%) *N sicca*, 1 (2.2%) *P mirabilis*, 1 (2.2%) GBS, 1 (2.2%) Viridans group streptococci, 1 (2.2%) No growth, 1 (2.2%)	
Masood et al, 2014 [37]	59 LVAD infections	Exclusively DLI and PPI	NR	0% mortality with pump exchange	NR	Pump exchange with omental transposition for confirmed PPI; had a 75% (21%) freedom from recurrence of device-related infections
Moazami et al, 2014 [79]	33 LVAD infections	DLI, 30.0% PPI, 6.0% BSI, 13.0%	NR	NR	NR	NR
Nelson et al, 2014	12 patients with at least	DLI, 50.0%	Multidisciplinary	50% mortality noted at	MSSA, 1	Complex wounds were associated

[80]	1 LVAD infection	Mediastinitis and LVAD exposure/erosion, 50.0%	surgical approach achieved salvage achieved in all cases	follow-up (post hospital discharge)	MRSA, 1 *Pseudomonas* spp, 4 *Parvimonas* spp, 1	with greater mortality, even after attempted surgical salvage
Nishi et al, 2014 [81]	2 LVAD infections	DLI, 1 BSI, 1	NR	NR	NR	NR
Raymer et al, 2014 [82]	NR	NR	NR	NR	NR	BMI >35 was associated with increased risk of infection
Sabashnikov et al, 2014 [8]	73 infections 37 LVAD infections	DLI, 95.0% PPI, 5%	NR	NR	27 organisms isolated *S aureus* (70%) *Enterobacter* spp (15%) Coliform spp (44%) *Pseudomonas* spp (48%) *Enterococcus* spp (15%) *Klebsiella* spp (22%) *S maltophilia* (19%) *Proteus* spp (19%) *Bacteroides* spp (7%)	Double tunnel was not associated with fewer driveline infections HeartMate II was associated with more infections than the HeartWare HVAD

					Citrobacter spp (15%) *S marcescens* (4%) *A baumannii* and *calcoaceticus* (4%) *Pantoea* spp (4%) *Chryseobacterium indologenes* (4%) VRE, 1/27 (4%) Anaerobic spp, 1/27 (4%) MRSA, 1/27 (4%) *Prevotella* spp, 1/27 (4%) *Peptostreptococcus* spp, 1/27 (4%) Group B β-hemolytic *Streptococcus*, 1/27 (4%) *Morganella morganii*, 1/27 (4%)	
Singh et al, 2014 [83]	NR	NR	NR	NR	MRSA and MSSA were the	DLI decreased with exposure of

					most commonly isolated organisms	only the silicone velour portion of the driveline
Subbotina et al, 2014 [84]	6 infections 2 LVAD infections	NR	Infection was associated with 33% mortality	NR	NR	NR
Takeda et al, 2014 [85]	NR	DLI, 21	NR	NR	NR	NR
Abou el ela et al, 2015 [86]	98 infections	DLI, 100%	NR	22% of those with a primary revision needed a second revision	*Pseudomonas aeruginosa*, 26% MSSA, 19% MRSA, 22%	The combination of driveline relocation into the rectus muscle, velour removal, and wound- vacuum therapy had better outcomes
Akhter et al, 2015 [34]	32 readmissions for infection; 21 were LVAD infections	DLI, 100%	NR	NR	NR	Infection was a leading cause of readmission in this cohort
Birks et al, 2015 [87]	113 infections	DLI, 49.6%	NR	NR	*S aureus* was the most common organism isolated in DLI	DLI rates in white vs nonwhites were similar

Fried et al, 2015 [11]	38 LVAD infections	DLI, 100%	NR	NR	NR	DLI was not associated with an increased risk of stroke or device thrombosis
Fudim et al, 2015 [88]	18 infections	DLI, 100%	NR	NR	NR	DLI was more common in those with external anchoring sutures, but this was not statistically significant after multivariate adjustment
Haeck et al, 2015 [89]	2 LVAD infections	DLI, 100%	NR	NR	NR	Both patients with DLI required hospitalization
Haglund et al, 2015 [45]	11 infections 5 LVAD infections	Sternal wound infection, 60% DLI/pump pocket infection, 40%	NR	NR	NR	More infections occurred in HeartMate II patients than in HeartWare HVAD patients (0.49 [0.70] vs 0.17 [0.68]; *P*=.001) Infection was the second most common cause of readmission after cardiac causes

Harvey et al, 2015 [90]	60 infections	DLI, 100%	NR	NR	NR	Risk of stroke was increased with infection and with postoperative sepsis
Henderson et al, 2015 [91]	27 infections	DLI, 100%	NR	NR	NR	Higher BMI was associated with an increased risk of infection
Imamura et al, 2015 [13]	24 LVAD infections	DLI, 23 PPI, 3	NR	1 pump exchanged (HeartMate II to Jarvik 2000) due to PPI	NR	Higher BMI was a predictor of readmission for infection
Krishnamoorthy et al, 2014 [92]	5 LVAD infections	BSI, 80%	NR	After lead extraction, 4 patients had a relapse of the BSI	*S aureus*, 20% *Enterococcus* spp, 40% *Pseudomonas* spp, 20% *Klebsiella* spp, 20% 40% were MDRO	CIED removal for LVAD infection is still associated with high rates of relapse of the infection and patient mortality
Lushaj et al, 2015 [93]	4 LVAD infections	NR	NR	NR	NR	BTT vs DT did not show a significant difference in infection rates
Majure et al, 2015 [9]	66 infection-related readmissions	DLI, 39 infections	NR	NR	NR	Patients with an HVAD had a significantly higher rate of

	27 LVAD-infection–related readmissions					hospitalization than patients with a HeartMate II for LVAD-related infections (HR, 2.90 (95% CI, 1.03-8.13, *P*=.04)
Maltais et al, 2015 [94]	NR	NR	NR	NR	NR	Infection overall decreased after 30 days, with 4.23 events/patient y in the first 30 d, and 1.06 events from 30-180 d, 0.97 events from 180-365 d. DLI did not change significantly over time
Matsumoto et al, 2015 [10]	NR	NR	NR	NR	NR	Freedom from infection at 12 mo was better with the HeartMate II (85%) than the Evaheart (46.2%)
McCandless et al, 2015 [95]	4 LVAD infections	DLI, 100%	NR	NR	*S aureus*, 2 *Achromobacter* spp, 1 *S marcescens*, 1	Fewer infections with silicone than with velour

McMenamy et al, 2015 [96]	No LVAD infections	N/A	N/A	N/A	N/A	No DLIs, even in patients with a BMI >35
Nishinaka et al, 2015 [18]	NR	0.36 DLI/patient year 0.04 PPI/patient year	NR	NR	NR	NR
Ono et al, 2015 [97]	NR	43% of those with BSA <1.5 and 16% of those with ≥1.5 BSA had DLI	NR	NR	NR	Smaller BSA was associated with more DLI
Potapov et al, 2015 [98]	NR	0.08 DLI/patient year	NR	NR	NR	Authors concluded that the HeartMate II has an acceptable associated complication and infection rate
Trachtenberg et al, 2014 [22]	45 infections	22 BSI originated from DLI 4, catheter-related BSI 4, UTI-related BSI	Persistent bacteremia, particularly *Pseudomonas*, was associated with all- cause	62% of BSI persisted after treatment with appropriate antibiotics and required chronic, lifelong oral suppression	*Pseudomonas* spp, 12 *S aureus*, 11 *E faecalis*, 5 *Candida* spp, 3 *E coli*, 1 *K pneumoniae*, 1	NR

			mortality and stroke		Other, 12	
Tsiouris et al, 2015[99]	41 LVAD infections	DLI, 9 PPI, 1 BSI, 31	NR	1 patient required a device exchange; all others treated with 6 wk of antibiotics without need for chronic suppression	DLI: *S aureus*, 5 CoNS, 2 *Pseudomonas* spp, 1 *Serratia* spp, 1 PPI: CoNS, 1 BSI: CoNS, 16 *S aureus*, 5 *Enterobacter* spp, 3 *Klebsiella* spp, 2 *Serratia* spp, 1 *Candida* spp, 2 Viridans group streptococci, 2	DLI infection did not alter risk of death

Van Meeteren et al, 2015 [12]	81 LVAD infections	DLI, 100% (other infections not included)	NR	DLI did not adversely affect survival or increase risk of pump thrombosis or stroke	NR	NR
Wus et al, 2015 [100]	NR	DLI, 0	NR	NR	NR	Driveline dressing changes varied from daily to weekly without any significant impact on DLI
Yoshioka et al, 2014 [101]	1 LVAD infection	DLI, 100%	NR	NR	NR	DLI was late onset (2 y post implant)
Yost et al, 2015 [19]	34 LVAD infections	DLI, 32.3% PPI, 8.8% BSI, 39.1%	NR	NR	NR	Infection rates in patients with and without delayed sternal closure were not statistically different

Abbreviations: BMI, body mass index; BSI, bloodstream infection; CIED, cardiovascular implantable electronic device; CoNS, coagulase-negative *Staphylococcus*; CRI, cardiac resynchronization device; DLI, driveline infection; DT, destination therapy; GPC, gram-positive cocci; MDRO, multidrug resistant organisms; MRSA, methicillin-resistant *Staphylococcus aureus;* MSSA, methicillin-susceptible *Staphylococcus aureus*; NA, not applicable; NR, not reported; PPI, pump pocket infection; UTI, urinary tract infection; VRE, vancomycin-resistant enterococcus; ±, with or without.

[a] Study reported both incidents.